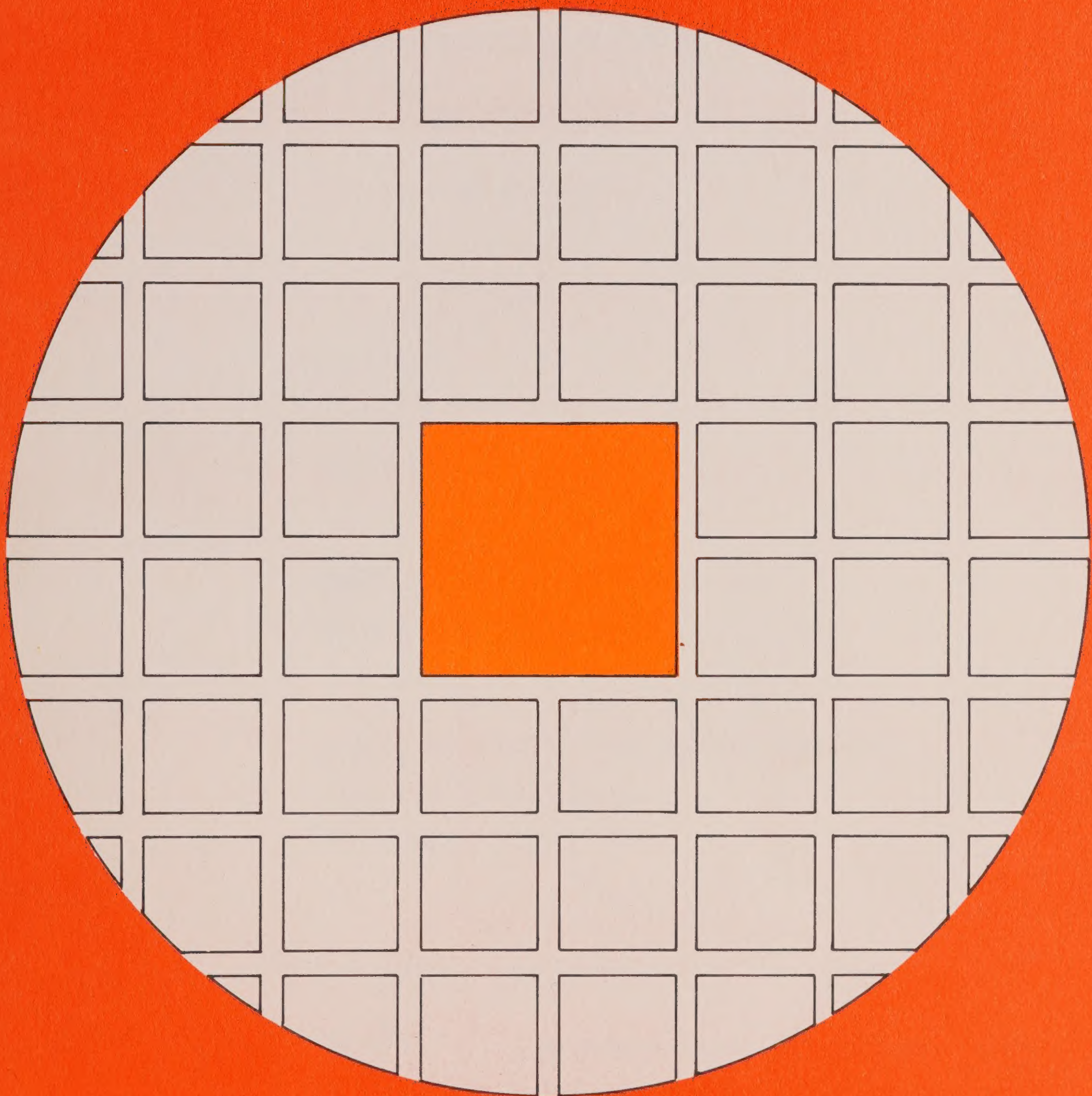
Ministry of Energy
Ontario

Energy Ontario

# Mississauga City · Centre

## ENERGY STUDY



Prepared for
Ontario Ministry of Energy
Region of Peel
City of Mississauga

# MISSISSAUGA CITY CENTRE

## ENERGY STUDY

PREPARED FOR

ONTARIO MINISTRY OF ENERGY

REGION OF PEEL

CITY OF MISSISSAUGA

BY

PRIME CONSULTANTS:

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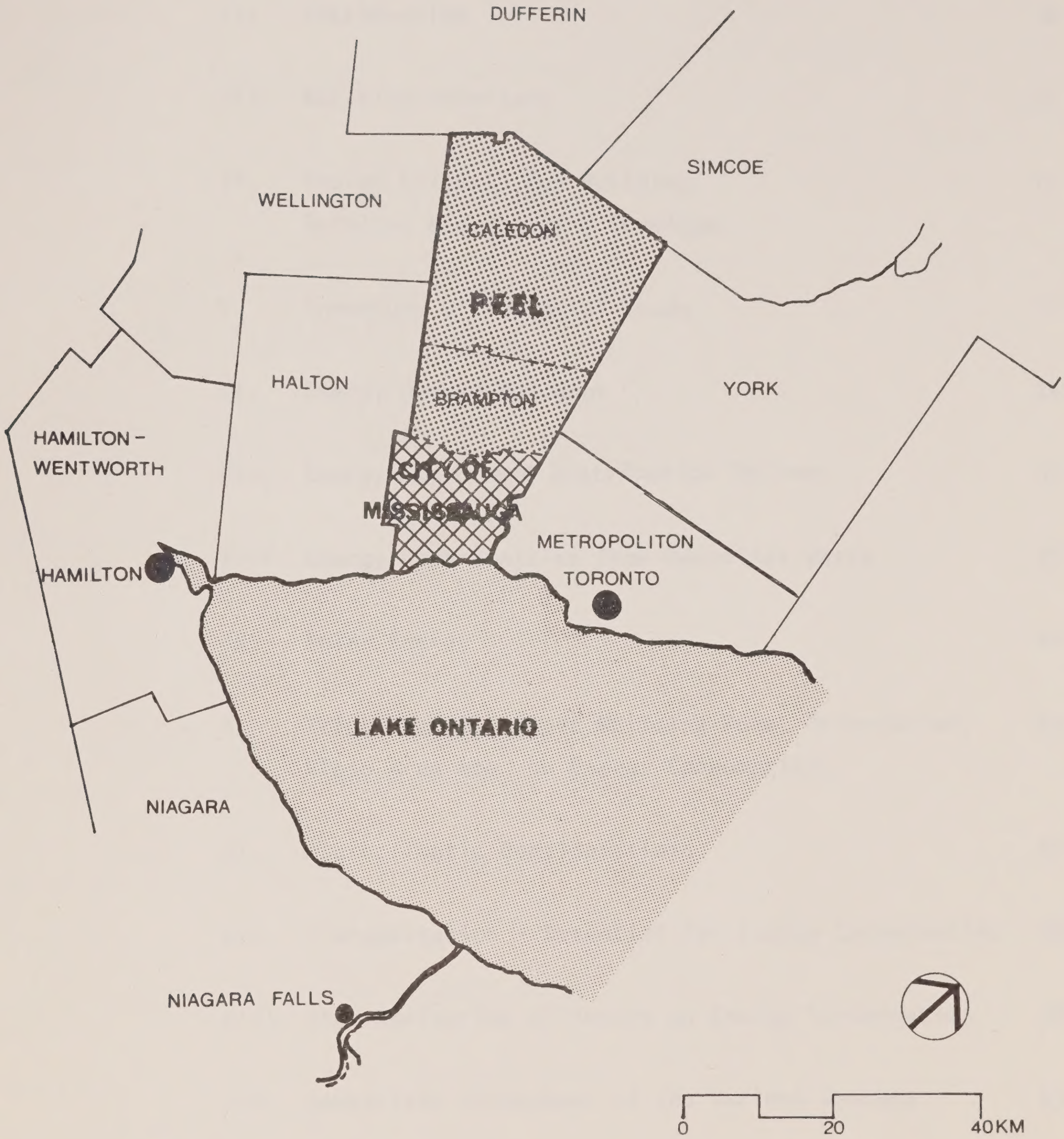
CITY OF MISSISSAUGA

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ABSTRACT

The Mississauga City Centre Energy Study examines those aspects of planning and building development that can be modified to improve the energy performance of new urban areas. Energy consumption modifiers such as, microclimate, landscaping, orientation, solar energy, building form, building detail, heat pumps, and thermal storage are investigated. The role of transportation, recycling, and tenure in energy use is commented on. Cost effective and energy efficient standards for construction and building systems are identified. Energy budgets are determined for each use and building parcel. The total energy requirement for the City Centre is computed and alternate means of servicing the energy burden are assessed. District systems for both heating and cooling are recommended as energy conserving and cost effective systems that warrant further study.

## 1. EXECUTIVE SUMMARY

The objective of the study is to assess the energy saving opportunities in planning and development. This study was conducted for the Ontario Ministry of Energy, the City of Mississauga and the Region of Peel by Henry Fliess and Partners, Architects and Okins, Leipciger, Cuplinskas, Kaminker and Associates Limited Consulting Engineers.

The prime consultants were assisted by DeLCan Consulting Engineers and Planners in the area of transportation and by Morrison, Hershfield, Theakston and Rowan Consulting Engineers; in the area of microclimate control. The study was carried out under the direction of a steering committee with members from The Ontario Ministry of Energy, The City of Mississauga, The Region of Peel, and S. B. McLaughlin Associates Limited.

The study was restricted in area to the planned City Centre as outlined in the "City of Mississauga City Centre Secondary Plan - Amendment 281" and in time to a 25 year span as determined by the steering committee.

As stated in the terms of reference:
"The City of Mississauga's plan for the City Centre outlines the preferred development pattern for the future core area. The Plan incorporates a number of functions, including residential, office, and retail units and envisages high density development in a defined area of approximately 178 hectares. The Ontario Ministry of Energy, the City of Mississauga and the Region of Peel have agreed that the Plan lends itself to an investigation at this time of energy-saving opportunities in areas such as building design and systems, construction, arrangement, and staging of development."

Although the study was not charged with the task of sett the final design for the City Centre it does attempt to identify the energy consumption implications of site planning and building design decision open to planners and developers. The study findings should form a useful guide in the ongoing development of the City Centre and should serve to underline the importance of the role of planning in the conservation of energy.

At the community scale the study provides a number of tools to architects and planners to enable them to judge the impact of building form, site planning and landscapin on the microclimate and the planned pedestrian precincts.

The improved pedestrian environment should encourage the citizens to use the City Centre and when coupled with the reduced energy costs should induce business to locate there to take advantage of the ongoing savings and security derived from a reduced dependence on energy.

Mississauga City Centre on completion will have a temperature controlled building floor area of over 2,400,000 $m^2$ and will represent a considerable demand for energy to maintain comfortable living and working conditions. Presently, nearly 90% of the City Centre is yet to be built and therefore it can still respond to planning decisions as to the choice of building standards, energy budgets, supply systems, fuel, built form, transportation policies and landscaping.

The study material was developed from operational data of existing City Centre buildings, data from Mississauga Hydro, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (A.S.H.R.A.E.), the National Research Council of Canada (N.R.C.C.), Okins, Leipciger, Cuplinskas and Kaminker computer simulations as well as from a number of federal and provincial energy reports and guidelines.

On completion, the City Centre will have a total heating energy consumption of 751,688 GJ per annum and a total electrical consumption of 1,416,909 GJ per annum.

If heated conventionally with individual boilers in each building the total investment, operating and fuel costs would be in the order of $80,000,000 over the 25 year time span used in the study.

Due to the size of heating demand and the rather concentrated urban plan form of the City Centre district or central heating becomes a very viable option as a means of supplying heat energy required.

If a central heating plant were constructed serving the entire City Centre then the total for investment, operating and fuel costs would be $64,000,000 for the same period, that is, a 20% savings.

Similarly the cooling requirements for the City Centre could be supplied from a central plant with total savings in the order of 35% over the conventional individual systems for each building.

The cost benefits for district sytems for heating and cooling are considered conservative and their use in the City Centre should be seriously considered. Further action in this regard should take the form of detailed economic and design studies to ascertain the appropriate system, location, timing, and funding arrangements required for the installations.

Further reduction in the total energy demand can be effected through modifications to the individual building form, energy systems, and the building envelope. Improved air tightness of the walls, reduced glass area and better insulation are confirmed as energy saving strategies at the individual building level. The use of heat pumps and storage tanks offer considerable energy savings potential. Buildings which are compact in their form are generally more energy efficient than those which by attenuation expose greater areas of exterior wall to the elements.

Care should be exercised in the use of the various building modifying strategies as their effective use must not be in conflict with the buildings' location, functions, and budgets. The use of heat pumps and storage tanks although energy efficient must be considered carefully from a cost benefit point of view, as their economics are influenced by many factors.

Utilization of the "free" heat from the sun will have limited application in the City Centre due to the unfavourable orientation of the road pattern some $45^{\circ}$ off the cardinal directions. However, when technically sound and cost effective collectors are available, then the extensive flat roof areas of the City Centre could be used for their placement.

The use of municipal waste from the City Centre as a heat source is possible but at this time appears to be costly and somewhat problematic. Greater value can be derived from a recycling program that would recover newsprint, fine paper and cardboard from the buildings. At current prices the total value of such recycled paper and cardboard would be in the order of $400,000 per year which is greater than its fuel value if burned for heat.

How the building forms and landscaped components are used in relationship to each other can have an effect on both the energy consumption of buildings and the viability of the pedestrian areas. Much is known of these effects and the knowledge should be applied to protect the walkway and open space system and thereby encourage walking between buildings rather than driving.

Energy savings through transportation policies seem to be more effective if exercised at the federal and provincial levels.

At the municipal level avoidance of traffic congestion, continuing improvements in public transit and adjustments to parking policies can be effective and warrant further study.

How buildings are used and operated can have dramatic effects on energy consumption. Energy conserving programs initiated by both the City of Mississauga and the Square One management have been effective and should be recognized, publicized and generally encouraged as models for other owners and building users.

With ever increasing insecurity in our fuel supply and the resulting escalation in energy costs it is becoming abundantly clear that we must take care in how our communities are planned and how they are used so that we may influence the future demand on our diminishing fuel resources.

Although the findings of this study are in the main site specific to the Mississauga City Centre, many of the findings have relevance to emerging urban areas in other parts of the Province. The standards suggested, the materials required and the technology implied are well within our ability and it only wants for recognition of the need for action and the resolve to take action.

## II. INTRODUCTION

### 1. Study Background

Mississauga is one of the fastest growing areas in the Metropolitan Toronto region. To distinguish it from other suburban areas it was deemed essential by many that a downtown focus had to be created. The desire to create a downtown core has grown with the confidence that Mississauga is indeed achieving greater self-sufficiency with an identity as the central focus for the Region of Peel. To achieve this goal the City has taken a number of major steps.

- In December 1975, Mississauga City Council passed a resolution calling for the development of a plan for the City Core.
- In August 1977, the Mississauga City Core Area Study, Phase One Status Report was presented to Council with Mississauga Core Area Study Phase Two following in September 1977.
- On August 13, 1979, the City Centre Secondary Plan Official Plan Amendment 281 was adopted by Mississauga City Council and by the Ministry of Housing on June 2, 1980. The objectives of the Plan are:
  - to provide an area of appropriate size and location for development as the focal point of retail, office, recreation, cultural, and institutional facilities;
  - to design a centre which will facilitate and attract a high level of social activity both day and night, have an attractive visual quality and a strong sense of identity;
  - to provide community facilities, including a City Hall, an area suitable for open air gatherings and other cultural activities;
  - to create a visual identity for the City by encouraging distinctive architectural themes for the built environment;
  - to provide transportation facilities which accommodate trips to the centre from other areas of Mississauga and the surrounding region;

- to be able to satisfy short term market and development preferences without compromising the long term potential of the centre;
- to provide a realistic plan which is workable over an anticipated development period of 20 to 30 years.

To accomplish these objectives, development and design policies were developed covering such issues as mixed use, pedestrian network, roadways, parking and public transit.

As part of the ongoing development and refinement of design policies it was deemed both appropriate and prudent to assess the City Centre Secondary Plan as to its total energy needs and methods of supplying those needs with the objective of minimizing consumption and energy costs.

In November 1979, the Ontario Ministry of Energy, the City of Mississauga and the Region of Peel commissioned Henry Fliess and Partners, Architects and Okins, Leipciger, Cuplinskas, and Kaminker Consulting Engineers to prepare a report detailing the energy consumption characteristics of the Mississauga City Centre Plan and to recommend means to improve energy efficiency.

## 2. Study Objectives

2.1 To define reasonable standards for design and construction of buildings incorporating energy conservation techniques, with reference to "Measures for Energy Conservation in New Buildings 1978". (National Research Council of Canada).

2.2 To conduct an inventory of the energy and power requirements and to determine preliminary energy budgets by type of function or use in the development area.

2.3 To assess and evaluate on technical, economic, and environmental grounds, various means of supply and distribution of energy to meet the requirements of the development area.

2.4 To outline preferred alternatives for energy supply and distribution and to recommend an appropriate work program and studies required to ensure energy efficiency in the design and engineering phase of City Centre development.

2.5 To assess the energy implications of the density mix, building heights, and arrangement of land uses and to describe an energy-efficient mix of uses in buildings, consistent with the City Centre Plan.

2.6 To suggest operational standards, particularly with respect to parking policy and internal movement, that will maximize the efficiency of the proposed transportation system.

2.7 Given the energy implications of the City Centre Plan, to identify opportunities for cost-effective energy savings and to develop a set of energy budgets as guidelines for architectural and engineering design of the City Centre.

3. Study Outline

3.1 Prepare an inventory of building floor areas by function for each development parcel.

3.2 Define design standards for building construction that are cost effective.

3.3 Determine preliminary energy budgets by type of function and use.

3.4 Prepare an estimate of potential energy loads for each building category and development parcel for:

- building space heating
- domestic hot water heating
- air conditioning
- electrical loads including street lighting

Identify loads by specific source requirements and further classify them as to the feasibility of alternate source options.

3.5 Develop overall energy demand profiles for each potential source of energy.

3.6 Review the potential of various energy supply and distribution systems to meet the heating and cooling requirements.

3.7 Compare the energy efficiency of a number of variations to the form, envelope, orientation, and systems of a building.

3.8 Comment on the potential of the alternate energy sources of municipal waste and solar heating.

3.9 Comment on the potential for energy conservation in the transportation sector.

3.10 Review the weather data relevant to the area and comment on how buildings and landscaping can be manipulated to reduce energy consumption and improve the microclimate for pedestrians.

3.11 Compare and assess systems of energy supply and distribution on the basis of technical, economic, and environmental implications.

3.12 Make recommendations as to design standards, energy budgets, and energy conservation techniques, required work program and further design studies.

Metric Values used through the study are based on the SI (International System of Units).

| PHENOMENON | SYMBOL | DESCRIPTION |
|---|---|---|
| Temperature | $^{o}C$ | degree Celsius |
| Heat (quantity) | J<br>kJ<br>MJ<br>GJ | joule<br>kilojoule (one thousand joules)<br>megajoule (one million joules)<br>giga joule (one thousand million joules) |
| Heat (power) | W | watt |
| Heat (demand) | $W/m^2$ | watts per square metre |
| Thermal Properties (R - Resistance) | $m^2\ ^{o}C/W$ | square metre degree Celsius per watt |

## III. BUILDING INVENTORY

### 1. Introduction

The energy requirements for Mississauga City Centre have been developed for functions and floor areas inherent in the distribution, uses and densities designated in "City of Mississauga City Centre Secondary Plan". Where the density designated was in units such as for housing or rooms in the case of hotels then appropriate unit and room floor area factors were used based on the extensive statistical data resources of the consultants. Where Gross Leasable Area was designated, as for retail, then the floor areas were adjusted upwards by some 15 to 20% to account for the required public and service spaces.

SUMMARY OF GROSS BUILDING AREAS ($m^2$)

| | |
|---|---|
| RETAIL | 454,811 |
| OFFICES | 1,170,300 |
| HOUSING | 599,800 |
| COMMUNITY | 54,000 |
| HOTEL | 150,000 |
| TOTAL | 2,428,911 $m^2$ |

SUMMARY OF PARKING

| | | |
|---|---|---|
| COVERED | 28,433 CARS | 909,856 $m^2$ |
| EXPOSED | 9,547 CARS | 305,504 $m^2$ |
| TOTAL | 37,980 CARS | |

See Table 1.and Appendix I for details.

# MISSISSAUGA CITY CENTRE BUILDING INVENTORY TABLE

| 1 Parcel Number | 2 Parcel Area (ha) | 3–4 Remarks | 5 RETAIL Gross [illegible] Area: Existing | 5 RETAIL: Ultimate (M²) | 6 Mall and Service Areas (M²) | 7 Gross Bldg. Area (M²) | 8 OFFICES Gross Building Area: Existing (M²) | 9 Elevators & Service Core (M²) | 10 Building Area (M²) | 11 Total Gross Building Area (M²) | 12 HOUSING Number of Units | 13 Gross Bldg. Area (M²) | 14 Community Facilities (Gross Bldg. Area M²) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.0 | | | | | | | | | | 200 | 20,000 | |
| 2 | 2.8 | | | 2.400 | 423 | 2,823 | | | | | 300 | 30,000 | 2,300 |
| 3 | 4.8 | | | 2,400 | 423 | 2,823 | | | | | 400 | 40,000 | 4,600 |
| 4 | 4.4 | | | 4,800 | 847 | 5,647 | | 1,395 | 7,905 | 9,300 | 200 | 16,000 | 4,600 |
| 5 | 1.3 | | | | | | | 6,975 | 39,525 | 46,500 | | | |
| 6 | 3.8 | | | 9,200 | 1,623 | 10,823 | | 6,975 | 39,525 | 46,500 | 200 | 16,000 | 1,850 |
| 7 | 4.0 | | | 27,100 | 6,775 | 33,875 | | 1,395 | 7,905 | 9,300 | 200 | 16,000 | 1,350 |
| 8 | 4.2 | | | 22,500 | 5,625 | 28,125 | | 3,480 | 19,720 | 23,200 | 150 | 12,000 | 1,350 |
| 9 | 3.0 | | | 900 | 159 | 1,059 | | 9,750 | 55,250 | 65,000 | 100 | 8,000 | |
| 10 | 5.2 | Study Block | | 9,200 | 1,623 | 10,823 | | 5,730 | 32,470 | 38,200 | 250 | 20,000 | 1,750 |
| 11 | 3.8 | Study Block | | 32,000 | 8,000 | 40,000 | | 3,480 | 19,720 | 23,200 | | | 2,300 |
| 12 | 5.4 | Study Block | 1,035 | 4,400 | 776 | 5,176 | 24,565 | 7,650 | 43,350 | 51,000 | | | 27,900 |
| 13 | 2.6 | | | 900 | 159 | 1,059 | | 9,060 | 51,340 | 60,400 | 150 | 12,000 | |
| 14 | 2.0 | | | 2,400 | 423 | 2,823 | | 4,185 | 23,715 | 27,900 | 200 | 16,000 | |
| 15 | 13.0 | Square one expansion | 3,740 | 69,500 | 23,166 | 92,666 | | 3,750 | 21,250 | 25,000 | 350 | 28,000 | 500 |
| 16 | 18.0 | Square one | 87,239 | 144,200 | 48,066 | 192,266 | | 10,050 | 56,950 | 67,000 | 350 | 28,000 | 900 |
| 17 | 2.8 | | | 2,700 | 476 | 3,176 | 8,178 | 5,565 | 31,535 | 37,100 | 100 | 8,000 | |
| 18 | 2.1 | | | 900 | 159 | 1,059 | | 11,130 | 63,070 | 74,200 | | | |
| 19 | 1.6 | | | 1,800 | 317 | 2,117 | | 2,790 | 15,810 | 18,600 | 150 | 12,000 | |
| 20 | 1.4 | | | 900 | 159 | 1,059 | | 5,100 | 28,900 | 34,000 | | | |
| 21 | 1.5 | | | 900 | 159 | 1,059 | | 1,185 | 6,715 | 7,900 | | | |
| 22 | 4.0 | | | 900 | 159 | 1,059 | 5,166 | 13,200 | 74,800 | 88,000 | | | |
| 23 | 7.5 | | | 13,000 | 2,294 | 15,294 | 53,305 | 13,950 | 79,050 | 93,000 | | | 4,600 |
| 24 | 2.1 | | | | | | | 6,960 | 39,440 | 46,400 | | | |
| 25 | 2.0 | | | | | | | | | | 500 | 40,000 | |
| 26 | 3.6 | | | | | | | 8,355 | 47,345 | 55,700 | 225 | 18,000 | |
| 27 | 3.1 | | | | | | | | | | 775 | 62,000 | |
| 28 | 8.2 | | | | | | | 10,095 | 57,205 | 67,300 | 240 | 19,200 | |
| 29 | 3.3 | | | | | | | 2,790 | 15,810 | 18,600 | | | |
| 30 | 8.8 | | | | | | | 9,405 | 53,295 | 62,700 | | | |
| 31 | 9.9 | | | | | | 28,996 | 11,145 | 63,155 | 74,300 | | | |
| 32 | 2.1 | | | | | | | | | | 460 | 41,400 | |
| 33 | 4.1 | | | | | | | | | | 920 | 82,800 | |
| 34 | 2.8 | | | | | | | | | | 680 | 54,400 | |
| TOTALS | 151.2 | | 92,014 | 353,000 | 101,811 | 454,811 | 120,210 | 175,545 | 994,755 | 1,170,300 | 7,100 | 599,800 | 54,000 |

| 1 Parcel Number | 15 HOTEL Number of Rooms | 16 Bedroom Area (M²) | 17 Ancillary Facilities (M²) | 18 Lobbies & Corridors (M²) | 19 Service Rms Kitchens etc. (M²) | 20 Total Gross Bldg. Area (M²) | 21 Total Ultimate Gross Building Area (M²) | 22 Max. Bldg. Height No. of Storeys | 23 Site Coverage Including Bldgs. and Parking % | 24 Area (ha) | 25 Building Basements (M²) (One Level) | 26 Number of Car Spaces Ultimate: Exposed | 27 Covered | 28 Total | 29 Area Req'd for covered (M²) | 30 Area Exposed |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | 20,000 | No limit | 60 | 1.2 | 1,253 | 50 | 150 | 200 | 4,800 | 1,600 |
| 2 | | | | | | | 35,123 | 12 | 60 | 1.68 | 2,776 | 106 | 315 | 421 | 10,080 | 3,392 |
| 3 | | | | | | | 47,423 | 4.6 + no limit | 60 | 2.88 | 5,627 | 131 | 390 | 521 | 12,480 | 4,192 |
| 4 | 400 | 21,000 | 6,000 | 1,500 | 1,500 | 30,000 | 65,547 | 4 + no limit | 100 | 4.4 | 8,743 | 252 | 756 | 1,008 | 24,192 | 8,064 |
| 5 | | | | | | | 46,500 | no limit | 80 | 1.04 | 3,100 | 128 | 383 | 511 | 12,256 | 4,096 |
| 6 | | | | | | | 75,173 | 6 + 12 | 80+100 | 3.53 | 8,663 | 277 | 829 | 1,106 | 26,528 | 8,864 |
| 7 | | | | | | | 60,525 | 4,6+12 | 100 | 4.0 | 7,915 | 367 | 1,100 | 1,467 | 35,200 | 11,744 |
| 8 | | | | | | | 64,675 | 6+12 | 80+100 | 3.78 | 8,346 | 343 | 1,029 | 1,372 | 32,928 | 10,796 |
| 9 | | | | | | | 74,059 | no limit | 80 | 2.4 | 5,030 | 214 | 639 | 853 | 20,448 | 6,848 |
| 10 | | | | | | | 70,773 | 6+12 | 80+100 | 4.84 | 8,252 | 267 | 798 | 1,065 | 25,536 | 8,544 |
| 11 | 600 | 31,500 | 9,000 | 2,250 | 2,250 | 45,000 | 110,500 | 4+12 | 100 | 3.8 | 14,112 | 596 | 1,785 | 2,381 | 57,144 | 19,072 |
| 12 | | | | | | | 84,076 | 6+12 | 100 | 5.4 | 10,509 | 265 | 792 | 1,057 | 25,344 | 8,480 |
| 13 | | | | | | | 73,459 | no limit | 80 | 2.08 | 5,037 | 213 | 639 | 852 | 20,448 | 6,816 |
| 14 | | | | | | | 46,723 | 12 | 80 | 1.6 | 4,126 | 153 | 457 | 610 | 14,624 | 4,896 |
| 15 | | | | | | | 146,166 | 6,12+ no limit | 100 | 13.0 | 14,441 | 904 | 2,709 | 3,613 | 86,688 | 28,928 |
| 16 | | | | | | | 288,166 | no limit | 100 | 18.0 | | 1,822 | 5,466 | 7,288 | 174,912 | 58,304 |
| 17 | | | | | | | 48,276 | 12 | 80 | 2.24 | 4,139 | 156 | 468 | 624 | 14,976 | 4,992 |
| 18 | | | | | | | 75,259 | no limit | 80 | 1.68 | 5,017 | 214 | 640 | 854 | 20,480 | 6,848 |
| 19 | | | | | | | 32,717 | 12 | 80 | 1.28 | 2,901 | 108 | 323 | 431 | 10,336 | 3,456 |
| 20 | | | | | | | 35,059 | no limit | 80 | 1.12 | 2,337 | 103 | 309 | 412 | 9,888 | 3,296 |
| 21 | 400 | 21,000 | 6,000 | 1,500 | 1,500 | 30,000 | 38,959 | " | 80 | 1.2 | 2,703 | 156 | [illegible] | 624 | 14,976 | 4,992 |
| 22 | | | | | | | 89,059 | " | 80 | 3.2 | 5,937 | 252 | [illegible] | 1,006 | 24,128 | 8,064 |
| 23 | | | | | | | 112,894 | " | 80 | 6.0 | 7,526 | 396 | 1,186 | 1,582 | 37,952 | 12,672 |
| 24 | | | | | | | 46,400 | " | 80 | 1.68 | 3,093 | 128 | 382 | 510 | 12,224 | 4,096 |
| 25 | | | | | | | 40,000 | " | 60 | 1.2 | 3,133 | 125 | 375 | 500 | 12,000 | 4,000 |
| 26 | | | | | | | 73,700 | " | 80 | 2.88 | 4,838 | 210 | 627 | 837 | 20,064 | 6,720 |
| 27 | | | | | | | 62,000 | " | 60 | 1.86 | 3,875 | 194 | 581 | 775 | 18,592 | 6,208 |
| 28 | 600 | 31,500 | 9,000 | 2,250 | 2,250 | 45,000 | 131,500 | " | 80 | 6.56 | 8,846 | 433 | 1,297 | 1,730 | 41,520 | 13,856 |
| 29 | | | | | | | 18,600 | " | 80 | 2.64 | 1,240 | 51 | 153 | 204 | 4,896 | 1,632 |
| 30 | | | | | | | 62,700 | " | 80 | 7.04 | 4,180 | 173 | 516 | 689 | 16,512 | 5,536 |
| 31 | | | | | | | 74,300 | " | 80 | 7.92 | 4,953 | 205 | 612 | 817 | 19,584 | 6,560 |
| 32 | | | | | | | 41,400 | " | 60 | 1.26 | 2,882 | 115 | 345 | 460 | 11,040 | 3,680 |
| 33 | | | | | | | 82,800 | " | 60 | 2.46 | 5,765 | 230 | 690 | 920 | 22,080 | 7,360 |
| 34 | | | | | | | 54,400 | " | 60 | 1.68 | 4,261 | 170 | 510 | 680 | 16,320 | 5,440 |
| TOTALS | 2,000 | 105,000 | 30,000 | 7,500 | 7,500 | 150,000 | 2,428,911 | | | | | | | 37,980 | | |

## SUMMARY OF GROSS AREAS (m²)

| | |
|---|---|
| RETAIL | 454,811 |
| OFFICES | 1,170,300 |
| HOUSING | 599,800 |
| COMMUNITY | 54,000 |
| HOTEL | 150,000 |
| TOTAL | 2,428,911 m² |

## SUMMARY OF PARKING

| | | |
|---|---|---|
| COVERED | 28,433 | CARS–909,856 m² |
| EXPOSED | 9,547 | CARS–305,504 m² |

## PARCEL MAP


Table 1.

## IV. DESIGN CRITERIA FOR BUILDING SERVICES AND BUILDING ENVELOPE.

### 1. Introduction

Design standards related to the planning, construction and use of buildings will have perhaps the greatest influence on the consumption of energy in the Mississauga City Centre. The long life of the built environment and the supporting infrastructure make it essential that the standards set are appropriate for the local climate and in tune with economically attainable building form and construction technology.

The geographic location of the City Centre is at $43^{\circ}$ northern latitude some seven kilometres north of the moderating influence of Lake Ontario. This suggests that climate data specific to the site should be used rather than that given for Mississauga in the Ontario Building Code (OBC). The OBC data is a weighted average for the whole municipality and is more appropriate to locations closer to the lake. Consultations with Environment Canada established that the Malton Airport data is appropriate for the City Centre location.

To respond to the given external environment appropriate criteria for internal environment, building services and building envelope must be set to assure reasonable comfort and energy savings. For the purpose of this study National Research Council of Canada (NRCC) Document No. 16574 "Measures for Energy Conservation in New Buildings" is used as the basic standard wherever possible. The NRCC standard is considered comprehensive and attainable,and covers buildings and functions not taken into account in the OBC. This standard should

serve well as a set of minimum requirements for the study area. Where appropriate the following list of standards has been arrived at through interpolation to tailor them more directly to the City Centre conditions.

For comparison other examples of codes and guidelines have been tabulated in chart form to indicate the relative requirements of the various standards. See Table 2 & 3 and Appendix II for detailed Design Criteria for Building Services and Building Envelopes.

2. Outdoor/Indoor Conditions

2.1 Outdoor Design Weather Conditions:

Winter ($2\frac{1}{2}\%$): - 18°C

Heating Degree Days: 4082

Summer ($2\frac{1}{2}\%$): 31°C Dry Bulb

23°C Wet Bulb

2.2 Indoor Conditions:

Winter - Retail, Sports, Auditoria and similar occupancies: 18°C*

Other occupancies: 20°C*

Summer - All occupancies with mechanical cooling: 25°C

* In cases where winter cooling is required space temperatures may rise up to 25°C.

COMPARISON OF OVERALL THERMAL RESISTANCE (R VALUE)

| BUILDING ASSEMBLIES | OBC* | CMHC* | | STANDARD COMMERCIAL PRACTICE | ASHRAE 90-75 | FINLAND | ONT.MIN.OF GOVERNMENT SERVICES | MISSISSAUGA CITY CENTRE (RECOMMENDED) | |
|---|---|---|---|---|---|---|---|---|---|
| | SOLID | 3 STOREYS OR LESS | MORE THAN 3 STOREYS | | | | | LOW INTERNAL ENERGY BLDG. | HIGH INTERNAL ENERGY BLDG. |
| | $\frac{m^2 . ^0C}{W}$ + | $\frac{m^2 . ^oC}{W}$ | $\frac{m^2 . ^oC}{W}$ | $\frac{m^2 . ^oC}{W}$ | $\frac{m^2 . ^oC}{W}$ | $\frac{m^2 . ^oC}{W}$ | $\frac{m^2 . ^oC}{W}$ | $\frac{m^2 . ^oC}{W}$ | $\frac{m^2 . ^oC}{W}$ |
| Wall | 1.4** (.9) | 2.5 | 2.0 | 1.8 | 1.5*** | 2.9 | 3.5 | 2.7 | 2.1 |
| Below Grade Wall | 1.1 (.9) | 1.6 | 1.6 | 1.1 | - | 2.5 | - | 1.6 | 1.6 |
| Roof or Ceiling | 2.5 (2.1) | 5.2 | 2.2 | 2.1 | 2.5 | 3.5 | 3.5 | 2.7 | 2.1 |
| Floor | 2.2 (1.8) | 4.7 | 2.2 | 2.1 | 2.4 | 3.5 | 3.5 | 2.7 | 2.1 |
| Slab on Grade | 1.1 (.9) | 1.0 | .8 | .9 | 1.0 | 2.5 | - | 1.0 | .8 |

* Residential type building only.

** Overall resistance calculated for typical wall construction, using insulation values required by OBC (in brackets).

*** Resistance calculated in accordance with ASHRAE 90-75 for wall with 40% glazing.

\+ Resistance - square metre degree Celsius per watt.

Table 2.

COMPARISON OF RECOMMENDED LIGHTING LEVELS
GIVEN IN DEKALUX (1 DEKALUX = .93 FOOTCANDLES)

| AREA | IES* (1977) | GERMANY (1972) | ENGLAND (1973) | SWEDEN | ONTARIO HYDRO | MINISTRY OF GOV. SERVICES | MINISTRY OF HEALTH | MISSISSAUGA CITY CENTRE (RECOMMENDED) |
|---|---|---|---|---|---|---|---|---|
| Corridors, Services Areas, or Public Areas | 10 - 30 | 6 - 12 | 5 - 20 | 10 | 10 - 20 | 13 - 20 | 11 - 22 | 10 - 20 |
| Large Circulation Areas (Malls) | 20 - 50 | 25 | 20 - 40 | 20 - 30 | 30 - 40 | 25 - 40 | 32 | 20 - 30 |
| Normal Reading Areas (Offices) | 30 - 75 | 50 | 50 | 30 - 50 | 50 - 70 | 40 - 65 | 55 | 50 - 60 |
| Prolonged Reading Areas | 75 - 100 | | | | | 65 - 100 | 75 | 60 - 80 |
| Critical Visual Task Areas (Drafting) | 150 - 200 | 100 | 75 | 100 | 90 | | | 80 - 100 |
| Supermarket | 100 - 200 | 75 | 50 | 50 | | | | 75 - 100 |
| Retail | 30 - 100 | 25 - 50 | 50 | 50 | | | | 50 - 75 |
| Parking - Indoors | 11 | 6 | | | 5 | | | 5 - 10 |
| Parking - Outdoors | 1 - 2 | | | | | | | 1 - 2 |

* Illuminating Engineering Society

## V. INVENTORY OF POTENTIAL ENERGY LOADS

### 1. Introduction

The energy load calculations for the floor area and functions involved were generated from a number of sources. For existing buildings in the City Centre, actual operational data were used. The energy requirements for the unbuilt portion were based on data derived from experience, Ontario Hydro A.S.H.R.A.E. and from Okins, Leipciger, Cuplinskas, Kaminker and Associates Ltd. computer simulations for residential and office requirements.

### 2. Basic Data for Energy Consumption Calculations

The demand and consumption of energy for each type of occupancy developed from the previously described sources is summarized in the following table:

Table 4.

| | ELECTRICITY | | DOMESTIC HOT WATER | | SPACE HEATING | |
|---|---|---|---|---|---|---|
| | Peak Demand W/$m^2$ | Consumption MJ/$m^2$/year | Peak Demand W/$m^2$ | Consumption MJ/$m^2$/year | Peak Demand W/$m^2$ | Consumption MJ/$m^2$/year |
| Housing | 13.75 | 198 | 12.5 | 144 | 46.6 | 198 |
| Offices | 45.00 | 396 | 5.0 | 16 | 37.0 | 183 |
| Retail | 57.90 | 1080 | 23.0 | 75 | 39.2 | 177 |
| Community Facilities | 51.50 | 725 | 14.0 | 45 | 38.1 | 180 |
| Hotel | 32.20 | 481 | 15.7 | 123 | 44.4 | 192 |

A more detailed discussion of the energy demand and consumption for various types of occupancy can be found in Appendix III.

### 3. Projected Annual Energy Consumption

The data from the Building Inventory discussed in Section III along with the data in Table 4 were used to develop the energy demand and consumption estimates for each parcel of land as given in Appendix IV.

The projected energy consumption summary for the ultimate size of City Centre is given in Table 5.

The general procedure was to store all of the building inventory data and the basic energy requirements data in a computer program developed for this specific purpose. The parcel by parcel and the overall annual energy requirements could thus be easily determined.

Figures 2 to 4 indicate graphically the density of the projected consumption of heating, electrical and total energy for each parcel of the City Centre. Figure 1. provides additional information in this regard in the form of floor area ratios for each parcel.

PROJECTED ENERGY CONSUMPTION SUMMARY

| | FLOOR AREA | | HEATING ENERGY CONSUMPTION | | ELECTRICITY CONSUMPTION | | HEATING ENERGY PEAK DEMAND | | ELECTRIC PEAK DEMAND | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $m^2$ | % | GJ | % | GJ | % | KW | % | KW | % |
| Retail | 454,811 | 19 | 114,567 | 15 | 491,196 | 35 | 28,289 | 21 | 26,334 | 25 |
| Offices | 1,170,300 | 48 | 312,329 | 42 | 542,998 | 38 | 56,003 | 42 | 55,428 | 54 |
| Housing | 599,800 | 25 | 205,132 | 27 | 118,760 | 8 | 35,448 | 26 | 8,247 | 8 |
| Community Facilities | 54,000 | 2 | 11,961 | 2 | 24,300 | 2 | 2,376 | 2 | 2,543 | 2 |
| Hotel | 150,000 | 6 | 107,700 | 14 | 94,200 | 7 | 12,195 | 9 | 6,315 | 6 |
| Parking | 911,176 | | | | 143,674 | 10 | | | 4,556 | 4 |
| Street Lighting | | | | | 1,781 | 0 | | | 113 | 0 |
| TOTAL | 2,428,911 * | | 751,688 | | 1,416,909 | | 134,311 | | 103,535 | |

* Excluding parking area.

Table 5.

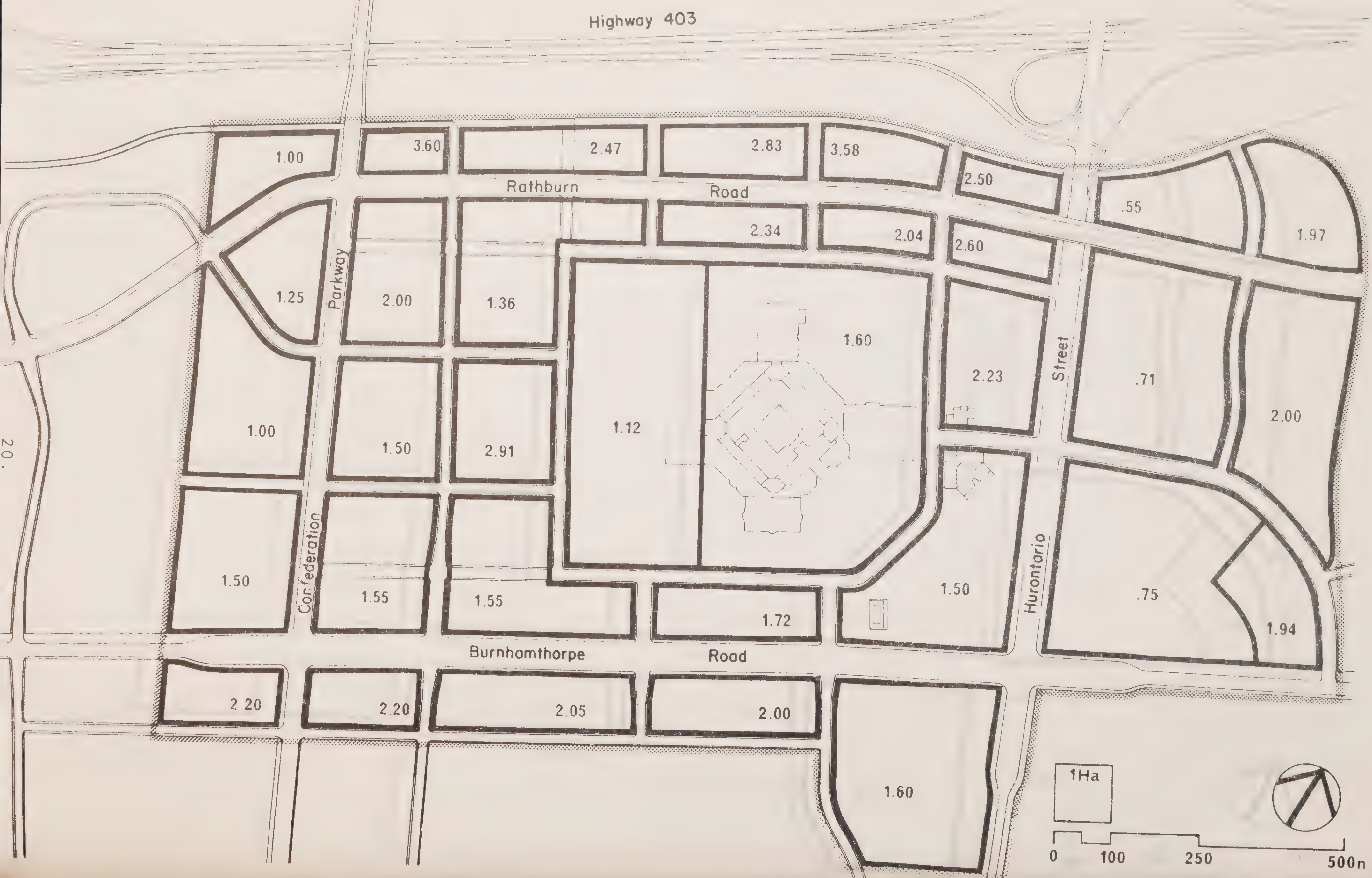
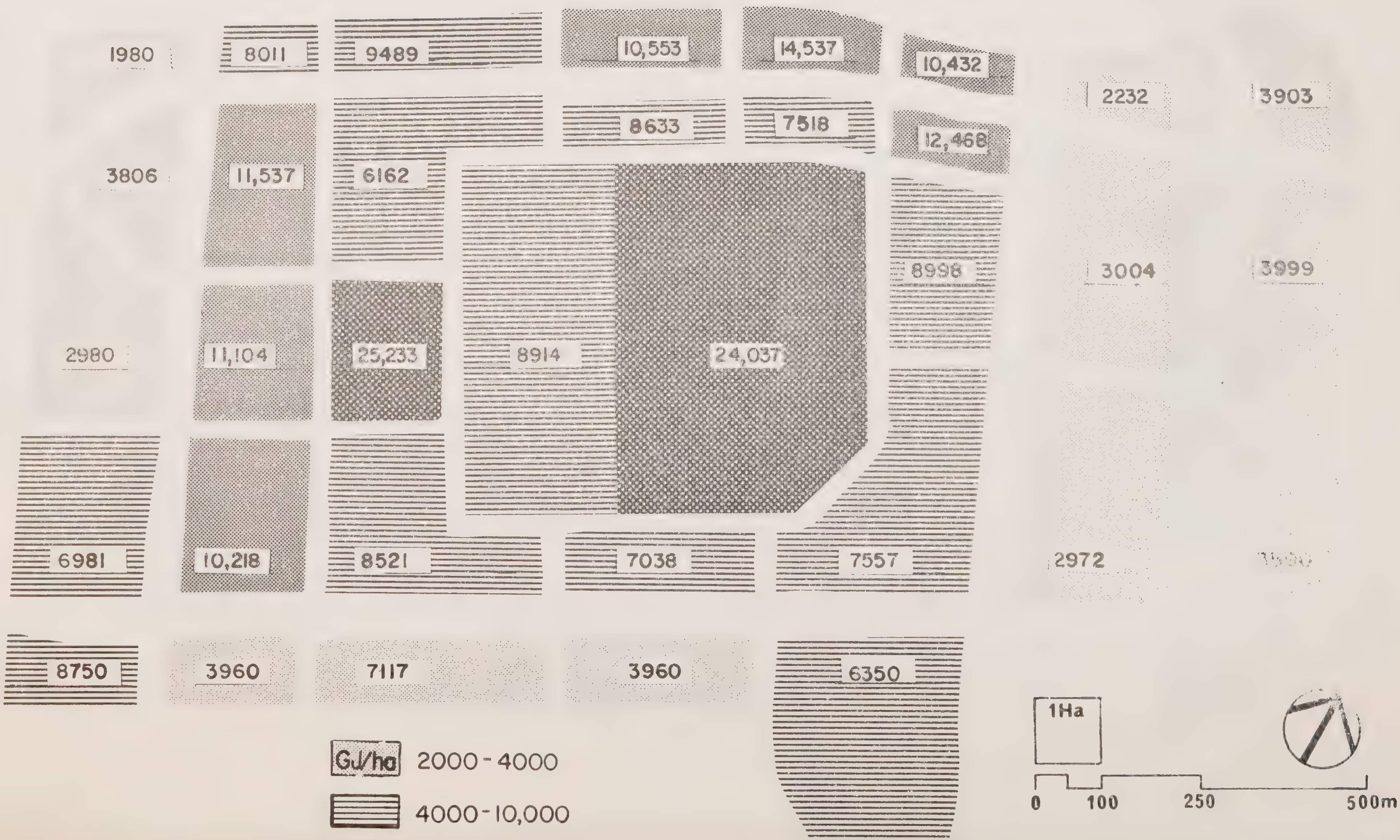



Figure 1

**FLOOR AREA RATIOS**


3420
7118
5313
6304
7159
5024
1122
6742
5868
5212
7526
4104
5956
3378
4425
1418
6905
3214
4040
9795
2924
3975
4371
3836
3285
3900
3120
1494
6202
4397
6840
4789
6840
4163
GJ/ha
1000 - 3000
3000 - 4500
4500 - 7500
7500-10,000+
1Ha
0
100
250
500m
PROJECTED ANNUAL
HEATING ENERGY / ha.

Figure 2.




PROJECTED ANNUAL ELECTRICAL ENERGY / ha

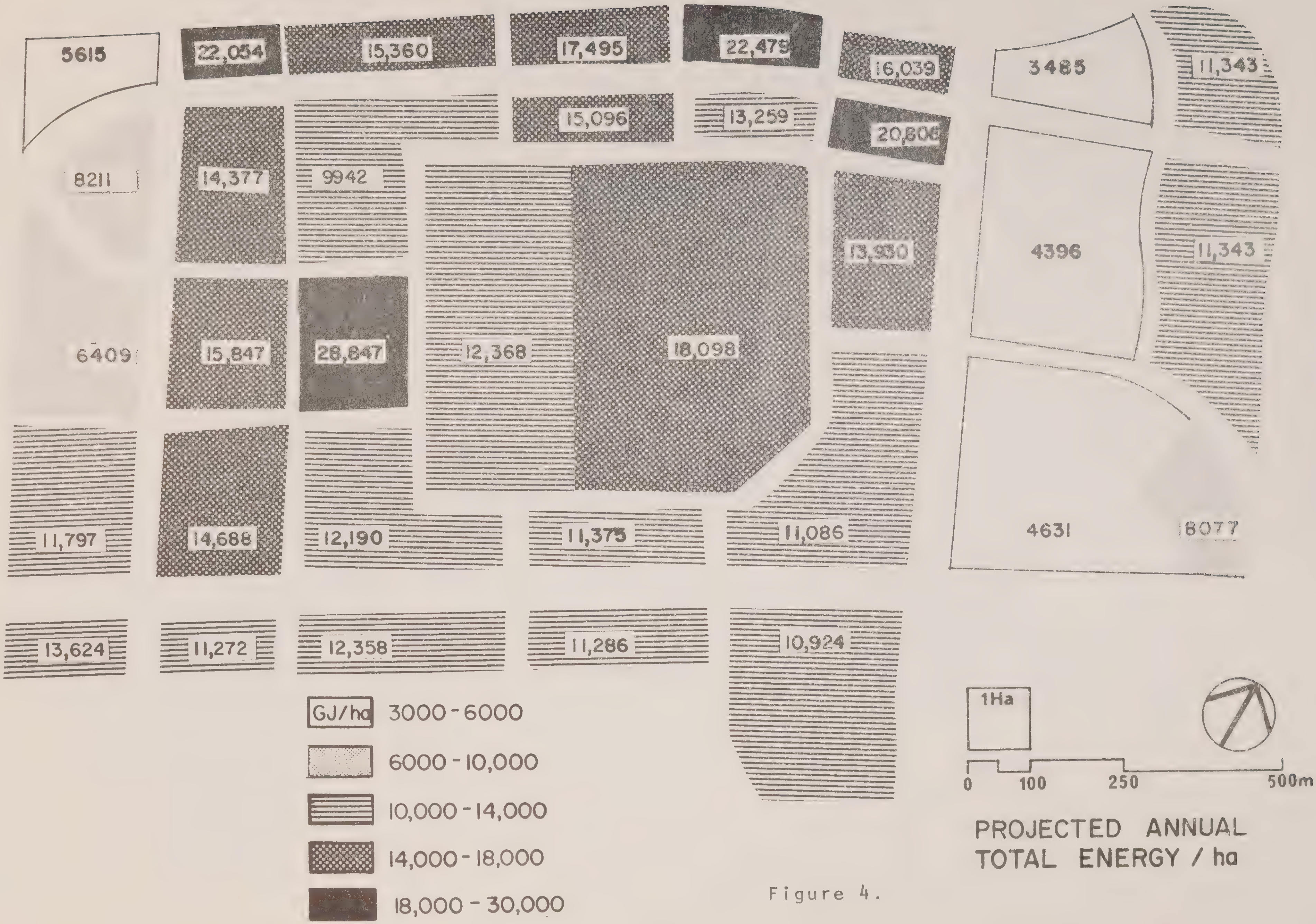

5615
22,054
15,360
17,495
22,479
16,039
3485
11,343
15,096
13,259
20,806
8211
14,377
9942
13,930
4396
11,343
6409
15,847
28,847
12,368
18,098
11,797
14,688
12,190
11,375
11,086
4631
8077
13,624
11,272
12,358
11,286
10,924
GJ/ha 3000 - 6000
6000 - 10,000
10,000 - 14,000
14,000 - 18,000
18,000 - 30,000
1Ha
0 100 250 500m
PROJECTED ANNUAL
TOTAL ENERGY / ha

Figure 4.

## VI. ENERGY DEMAND PATTERNS

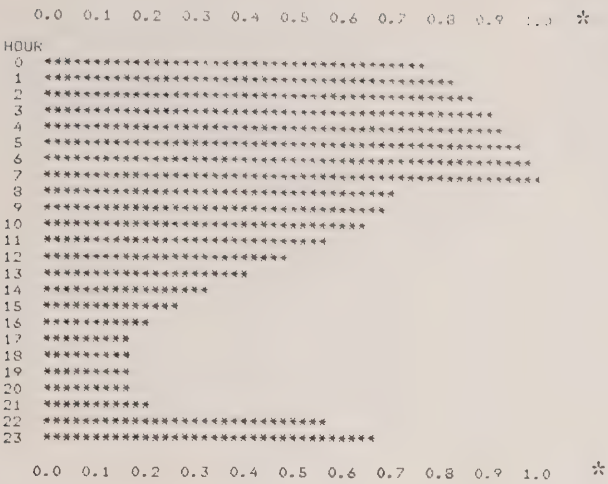
Figures 5 to 9 are graphical representations of the hourly patterns for electrical and heating energy demand by the various categories of occupancy. Both summer and winter demand patterns are estimated so that the appropriate design (maximum demand) day patterns for each source of energy could be determined. These patterns in conjunction with the data in Tables 1 (building areas) and 4 (energy demand) yield the overall heating and electrical hourly demands.

The overall heating energy demand for the ultimate size of the City Centre is indicated on Figure 10. This hourly pattern represents the demand for the district heating plant on a cold winter day. The contribution of each occupancy type to such hourly demand is indicated in the graph. The graph was obtained by numerical summing of the products of floor areas of the various occupancies, maximum estimated demands for each occupancy and the hourly patterns for such demands for each occupancy presented in earlier sections. Since each building of a given occupancy cannot be expected to follow the typical hourly pattern exactly, an additional diversity factor of 70% was applied to obtain the overall demand. The heating energy demand includes both space heating and domestic hot water heating.

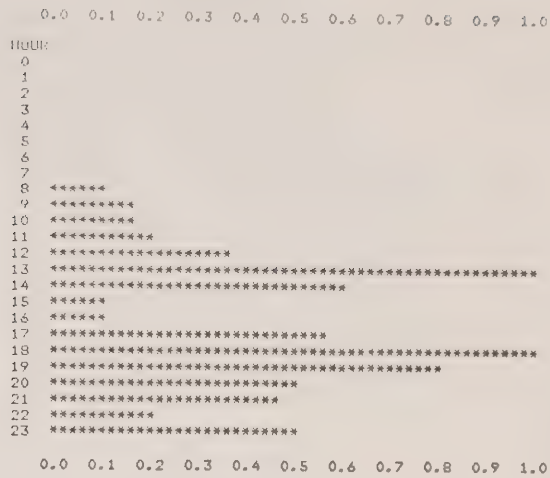
The overall electrical energy demand is indicated in Figure 11. This graph was obtained in a manner similar to that for the heating demand graph. The pattern includes all electrical consumption for the ultimate size of the development for a maximum summer cooling day. No reduction in load due to the use of heat pumps or storage tank systems is included.

RETAIL

HOURLY DEMAND FOR SPACE HEATING

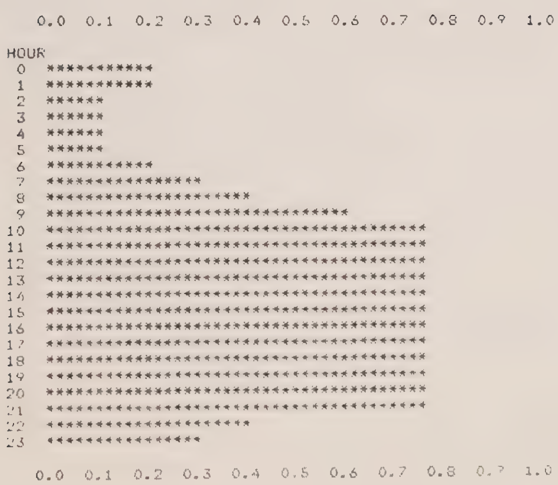


HOURLY DEMAND FOR DOM HOT WATER HEATING

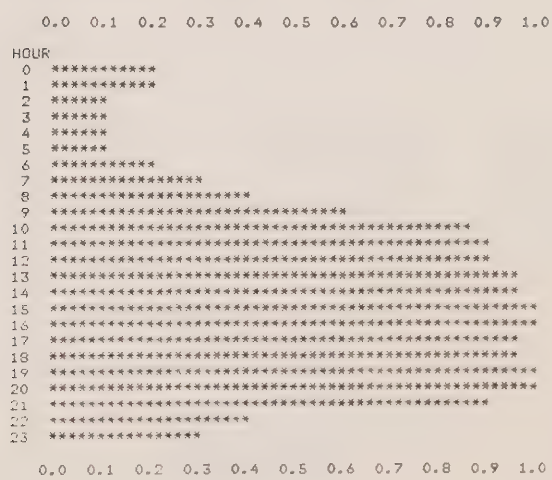


* Hourly demand is given in terms of a fraction (0.0 to 1.0) of the peak demand listed in Table 4.

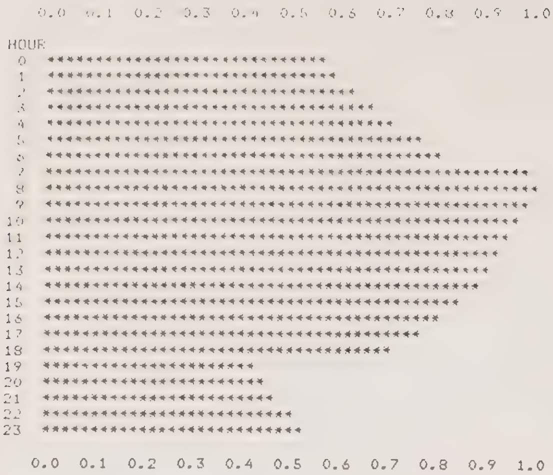
HOURLY DEMAND FOR ELECTRICITY - WINTER



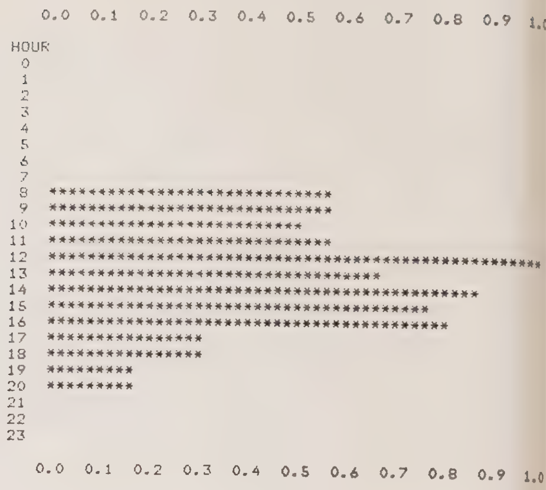
HOURLY DEMAND FOR ELECTRICITY - SUMMER



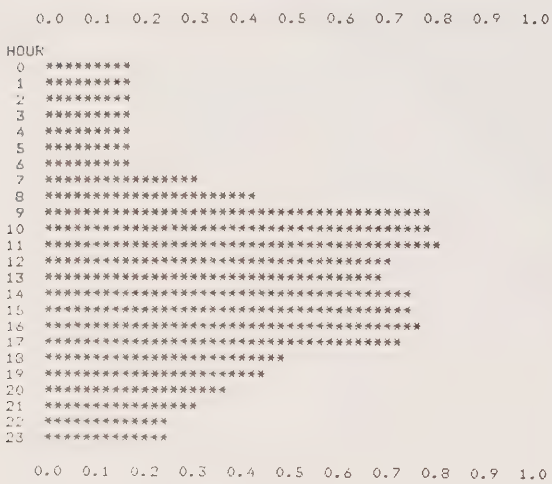
HOURLY DEMAND FOR SPACE HEATING



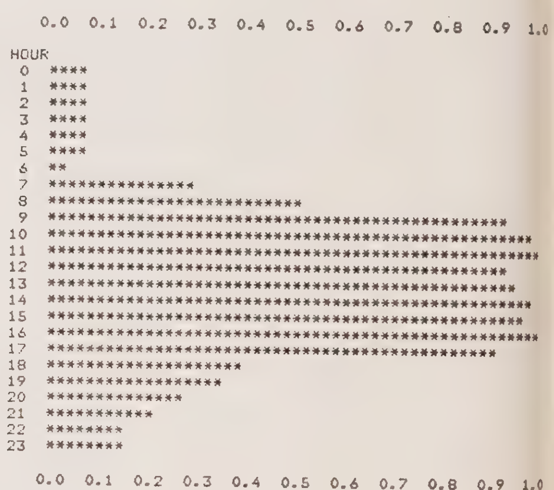

HOURLY DEMAND FOR DOM HOT WATER HEATING



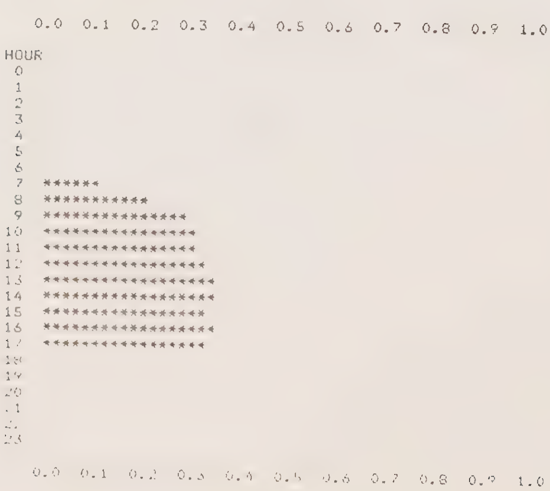

HOURLY DEMAND FOR ELECTRICITY - WINTER




HOURLY DEMAND FOR ELECTRICITY - SUMMER

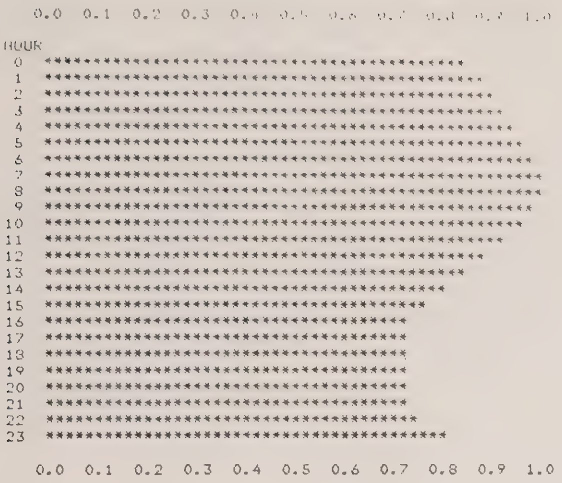



HOURLY DEMAND FOR AIR CONDITIONING



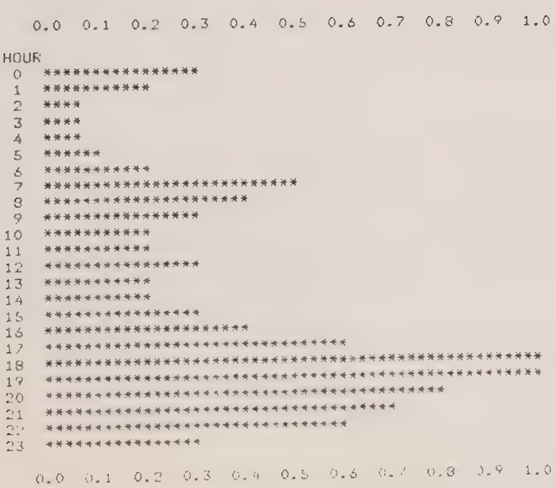
## HOUSING

HOURLY DEMAND FOR SPACE HEATING



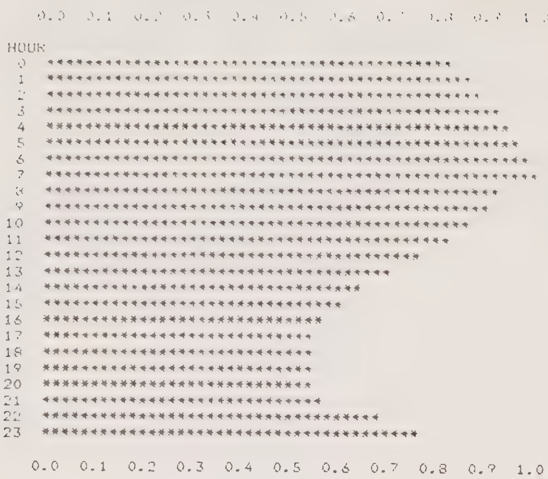

HOURLY DEMAND FOR DOM HOT WATER HEATING


HOURLY DEMAND FOR ELECTRICITY

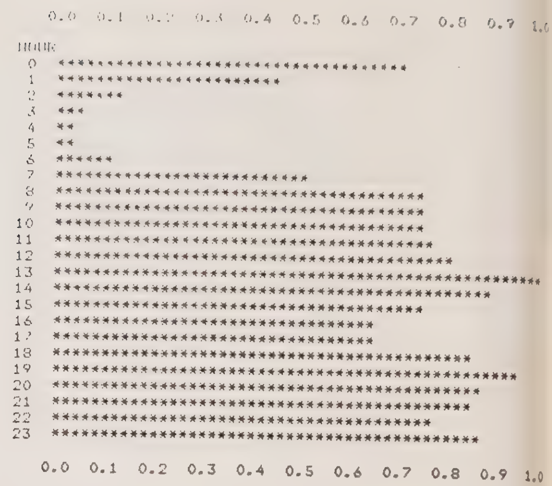


HOTEL

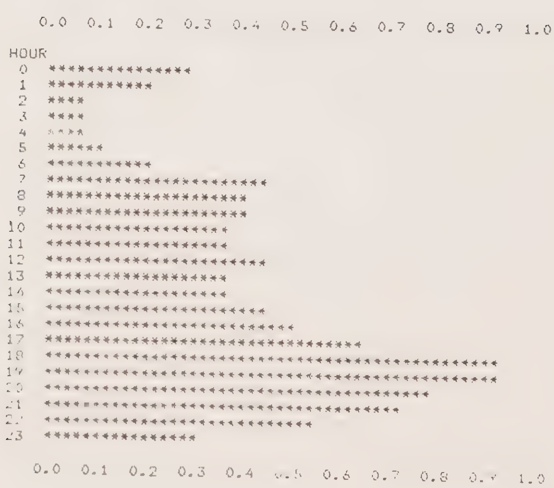
HOURLY DEMAND FOR SPACE HEATING



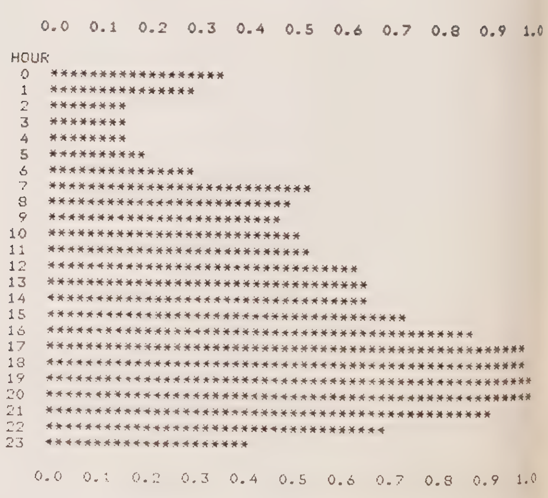

HOURLY DEMAND FOR DOM HOT WATER HEATING




HOURLY DEMAND FOR ELECTRICITY - WINTER

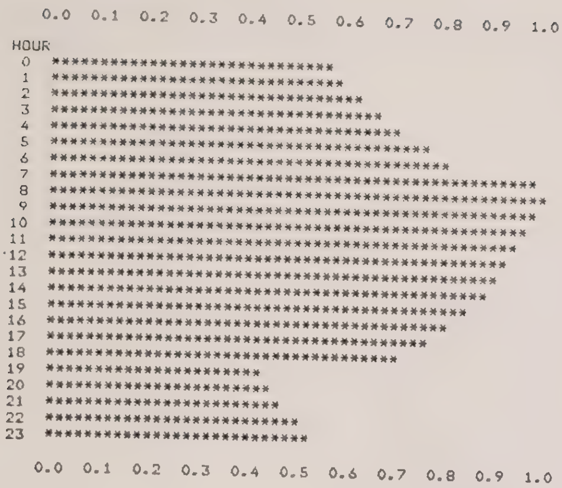



HOURLY DEMAND FOR ELECTRICITY - SUMMER

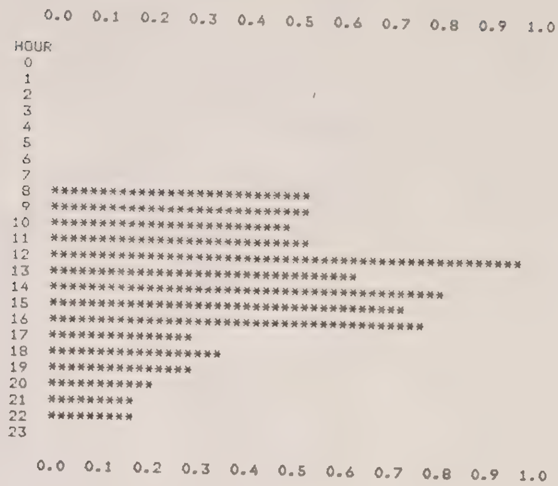


COMMUNITY

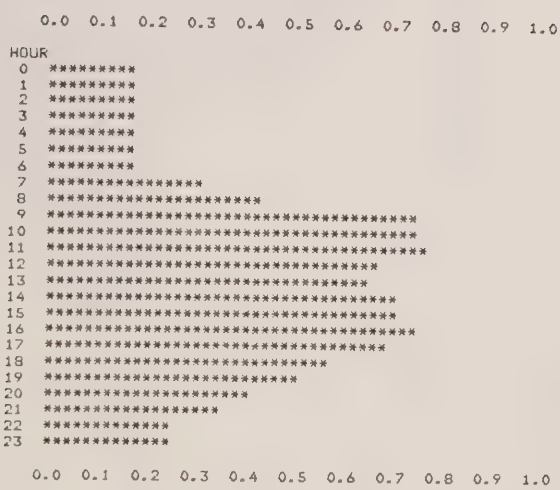
HOURLY DEMAND FOR SPACE HEATING




HOURLY DEMAND FOR DOM HOT WATER HEATING



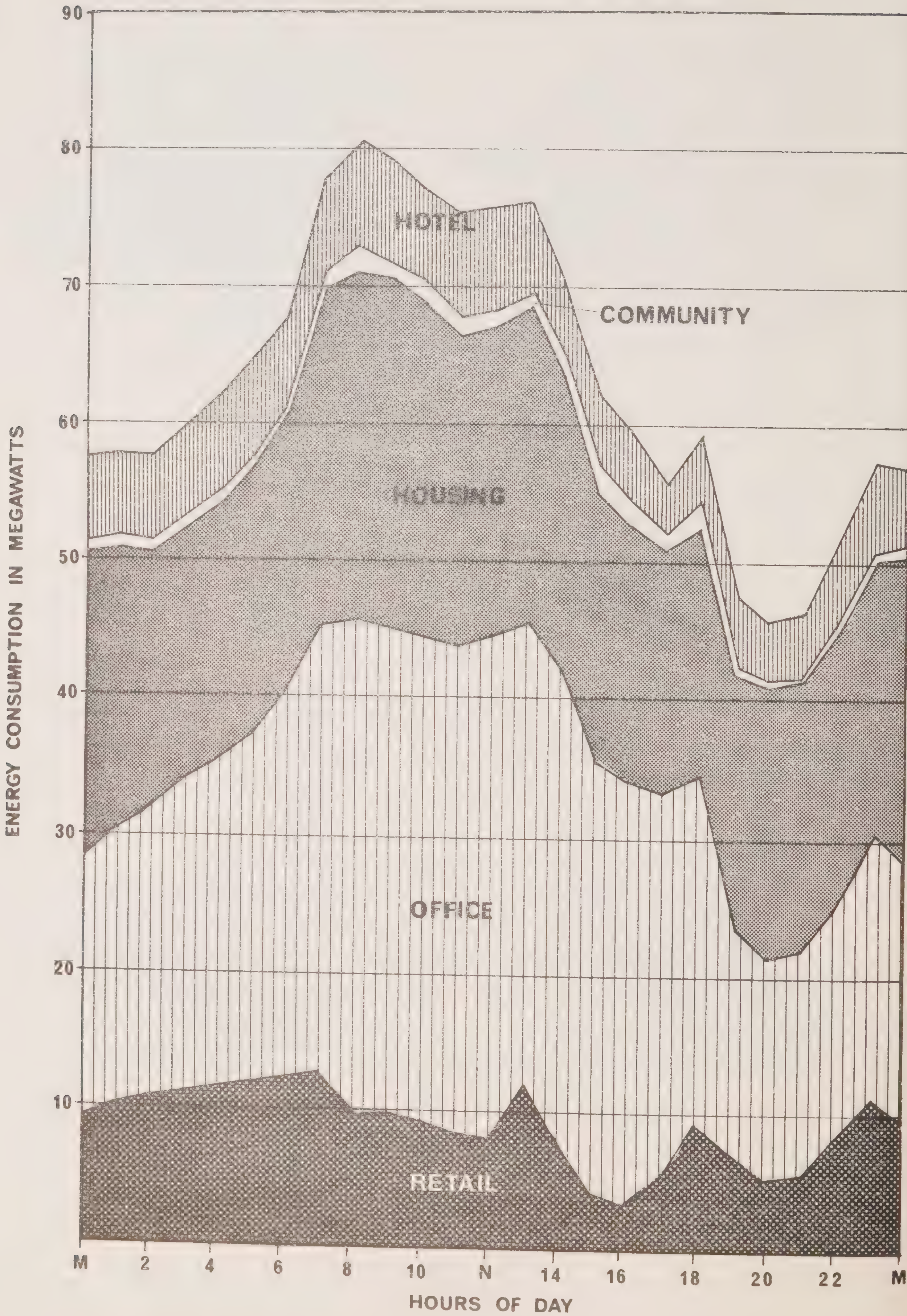

HOURLY DEMAND FOR ELECTRICITY - WINTER




HOURLY DEMAND FOR ELECTRICITY - SUMMER

Figure 10.

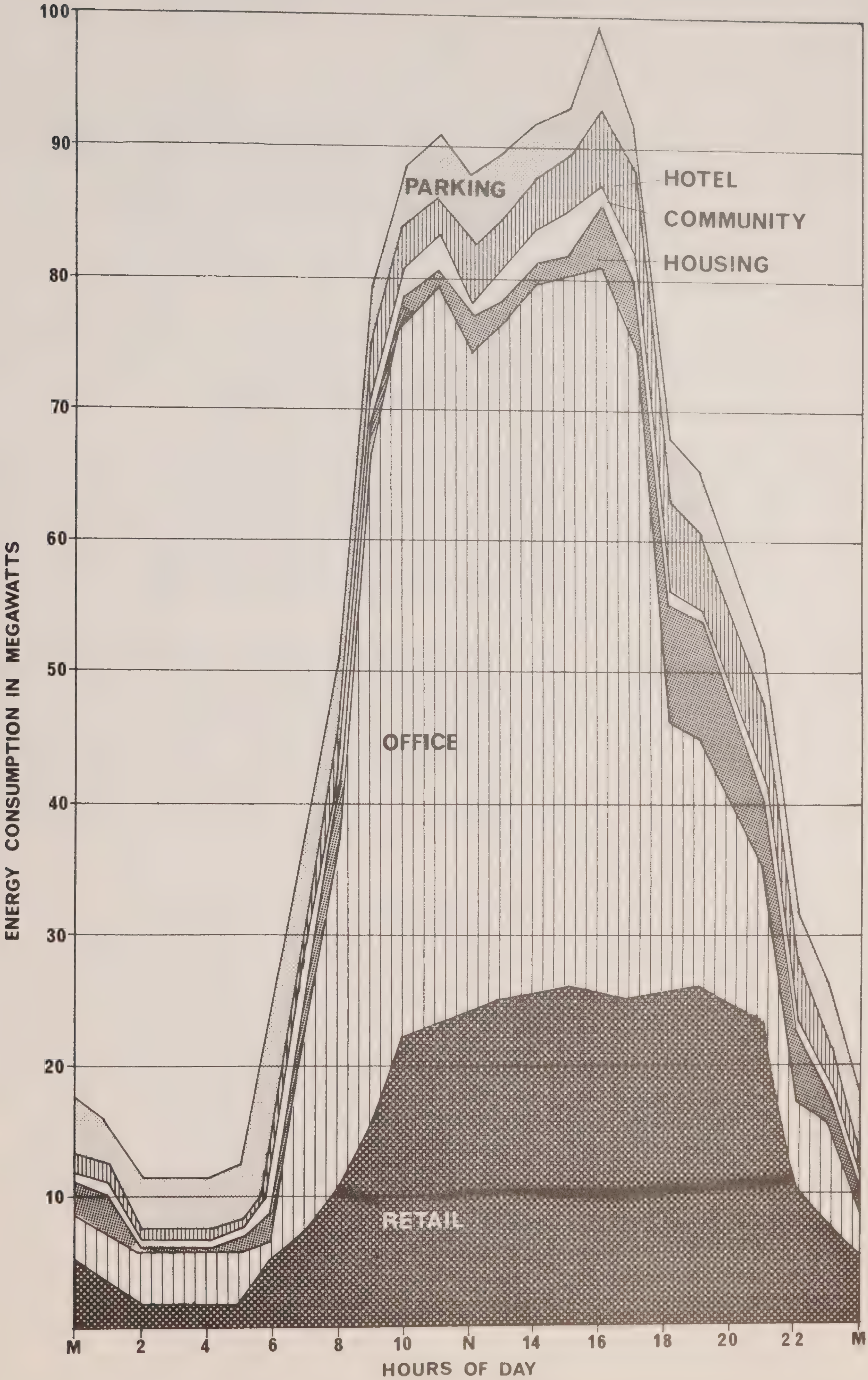
HEATING ENERGY PATTERN - WINTER HEATING DESIGN*




*NOTE: INCLUDES ENERGY FOR DOMESTIC HOT WATER HEATING

ELECTRICAL ENERGY PATTERN - SUMMER*

Figure 11.




*NOTE: PATTERN IS FOR A MAXIMUM COOLING SUMMER DAY

## VII. ENERGY SUPPLY AND DISTRIBUTION OPTIONS

### 1. Introduction

A number of energy supply options judged to be applicable were considered. The options reviewed ranged from the conventional individual systems for each building block, through a central system for the entire City Centre as well as a cursory review of the potential of energy from municipal waste and solar collectors.

A description of the fuel options and comparative system economics is presented for both individual and central systems for heating and cooling.

The Life Cycle Cost Calculations for the district heating and cooling systems are based on the assumption that the charges to the customers would be at the cost of production and that there would be no interference by regulatory authorities in the setting of the rates.

### 2. Description of Systems For Heating and Cooling

#### 2.1 Individual Building Block Plants

The principle of the system is that each individual building would be serviced by its own self-contained system using natural gas or light oil for heating and electricity for cooling.

#### 2.2 District System - Heating

The total heating and hot water requirements for the City Centre would be provided by one heat plant located within the plan area. The district plant would be an installation of multiple boilers using natural gas or residual oil providing hot water to all buildings via a network of circulation pipes. Municipal waste generated in the City Centre could be incinerated by the use of special boilers, however, an analysis of the waste quantities involved and the small amount of heat produced by incineration of such waste suggested that no further analysis be carried out for this limited scheme. However, a system drawing on the waste from

the Region could well be economical and warrants further consideration.

## 2.3 District System - Cooling

The total cooling requirements for the City Centre would be provided by one cooling plant located within the plan area. The district plant would be an installation of multiple chillers using electricity to provide all buildings with chilled water via a network of circulation pipes.

## 3. District Heating vs. Individual Building Heating Life Cycle Cost Analysis

The general approach was to assume that the City Centre would grow at a constant rate to its estimated projected size in 25 years. ( The possible alternate growth pattern of slow initial growth and accelerated later growth was not used as it would unduly favour the district heating system case.)

The energy costs were assumed to escalate in accordance with the predictions of the Ministry of Energy Strategic Planning and Analysis Department namely:

| | | | |
|---|---|---|---|
| Gas and Oil | - | 4.5% | (over inflation) |
| Electricity | - | 1.0% | (over inflation) |

The above rates are in terms of constant 1980 dollars. General inflation is not considered in the analysis as it has no effect on the final results of the Life Cycle Cost calculations as long as the discount rates used are also in terms of constant dollars.

Two discount rates are included in the calculations, namely 2% over inflation, considered to be appropriate for government institutions, and 6% over inflation, considered to be appropriate for private investors. It was found that the two discount rates did not affect significantly the comparison of the district vs. individual heating systems, although the absolute dollar amounts changed substantially.

In order to make the comparison conservative, several other assumptions were made that favour somewhat the individual systems. While capital expenditure for the individual systems was assumed to proceed at a uniform rate over the years, for the district heating system it was assumed that it would have to be prebuilt in five steps five years apart, i.e. for four years out of five the district heating system would be oversized for the gradually growing demand. Similar assumptions were used for the staffing expenses, only here it was assumed that in the first year the central plant would be fully staffed and the staff would double over 20 years in four intervals of five years each.

Fuel usage increases uniformly each year in accordance with the size of the development. The district heating system was assumed to have a 5% advantage in the overall combustion/utilization seasonal efficiency. The district heating plant has another advantage regarding fuel costs, in that the unit costs are lower. Utilities charge special lower rates to large volume customers.

Using the 2% discount rate the 25 years life cycle costs of the two systems compare as follows:

| | DISTRICT HEATING | INDIVIDUAL HEATING |
|---|---|---|
| Investments | $7,952,765 | $10,697,801 |
| Staff | 3,582,259 | 6,128,371 |
| Maintenance | 2,289,196 | 1,788,435 |
| Fuel | 50,306,984 | 62,192,700 |
| Total | $64,131,204 | $80,807,307 |

Life Cycle Costs of electric heating were found to be similar to those for the individual plant heating using fossil fuels. They are however considerably higher than the district heating system Life Cycle Costs.

NOTE: Details for the economic comparison of district heating and individual heating cases are given in Appendix V.

4. District Cooling vs. Individual Building Cooling Life Cycle Cost Analysis

Very similar assumptions to those discussed in the preceding chapter on district heating were used for the district cooling system comparison. Again the central system has an advantage in unit energy costs built into the hydro utility's rate structure.

Using the 2% discount rate the 25 year life cycle costs of the two systems compare as follows:

| | DISTRICT COOLING | INDIVIDUAL COOLING |
|---|---|---|
| Investment | $10,976,473 | $16,887,072 |
| Staff | 1,192,892 | 2,670,730 |
| Maintenance | 3,147,646 | 2,384,580 |
| Fuel | 16,310,105 | 26,946,162 |
| Total | $31,627,116 | $48,888,544 |

Note: Details for the economic comparison of the district cooling and the individual building cooling cases are given in Appendix VI.

5. Conclusion:

From the life cycle cost analysis it is clear that district systems for both heating and cooling have very attractive cost savings potential.

In the case of district heating the overall cost savings over the twenty-five year time frame would be in the order of 20% when compared to the individual building block systems.

In addition to the cost savings there are energy savings due to the fuel efficiency characteristics of the district systems which are better than those for individual building block plants.

In the case of district cooling the overall cost savings would be in the order of 35% when compared to the individual building block systems.

It is clear that the cost savings for central systems for both heating and cooling are significant and their use should be seriously considered for the future development of the City Centre.

## VIII. ENERGY OPPORTUNITIES FROM MUNICIPAL WASTE

### 1. Introduction

The municipal waste generated by the retail, office and housing components of the City Centre will generate, on completion, in excess of 20,000 tonnes of garbage per year.

Along with the fuel potential of waste is a considerable opportunity for the recovery of valuable resource materials. From consultations with the Ministry of Environment Waste Management Branch it was determined that the source recovery of newsprint, fine papers and corrugated cardboard might best suit the Mississauga City Centre area.

The energy potential of the City Centre waste then is assessed as to its value in terms of recoverable material as well as the fuel value of the residue wastes after the recycling exercises.

### 2. Value of recycled waste: (Per Year)

| | | | |
|---|---|---|---|
| a) | Residential newsprint | - | \$8,500 to \$14,300 |
| b) | Office fine paper | - | \$192,500 |
| c) | Commercial corrugated cardboard | - | \$161,480 to \$201,850 |
| d) | Total value per year | - | \$370,980 to \$408,650 |

NOTE: See Appendix VII for general notes.

3. Residue waste available for other energy related uses:

| | | | |
|---|---|---|---|
| a) | Residential | - | 4933 tonnes |
| b) | Office | - | 4065 tonnes |
| c) | Commercial | - | 7343 tonnes |
| d) | Total | - | 16,341 tonnes / year |
| e) | 45 tonnes per day | | |

Incineration of Municipal Waste

Heat content of refuse 11.6 MJ/kg or 11.6 GJ/tonne

Efficiency of combustion can be about 67%, but since recoverable (higher grade) waste is already removed, assume 60% combustion efficiency

| | | |
|---|---|---|
| Recoverable heat | - | 7 GJ/tonne |
| Average burning rate | - | 45 tonnes/day<br>or 1.875 tonnes/hr. |
| Recovered heat rate | - | 1.875 x 7 = 13.125 GJ/hr or<br>= 3.65 MW |

This rate of heat represents 4.56% of the capacity of the 80 MW district heating plant.

Such heat production would barely cover the heat losses of the distribution system and therefore could be fully utilized during all seasons, including summer.

(If all the refuse, including the recoverable waste, were incinerated, then the output of such an incinerator/ boiler would amount to 4.6 MW, or 5.75% of the district system capacity. This heat rate is still below the estimated domestic hot water demand and the piping system losses).

Note that heat derived from 1 tonne of refuse equals heat that can be derived from 0.22 tonnes of fuel oil. The waste material that is recovered (paper and cardboard) is worth more per tonne than the equivalent fuel value of the waste per tonne.

## 4. Conclusion:

The value of the recoverable waste materials warrants serious consideration on the part of both the municipality and the private sector to undertake a source separation paper recovery program. In addition to the revenue from the paper recovery program energy conservation and environmental benefits will be supported.

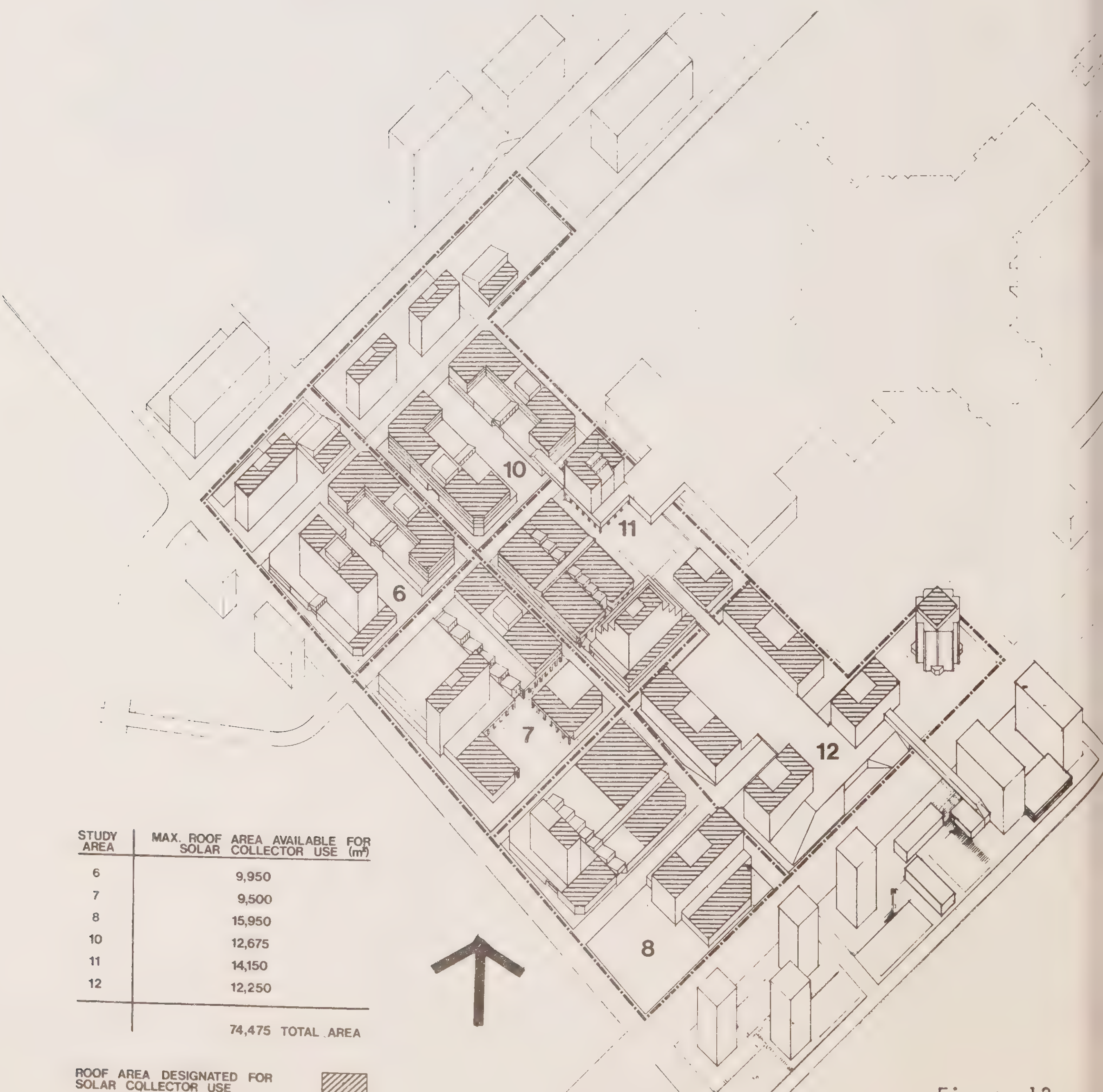
There will be a reduced need for land-fill sites, reduced need for pulp wood, and a reduced need for energy as the manufacture of paper from paper is more efficient than its original manufacture from pulp wood.

The residue waste left after the material reclamation program has an energy potential equivalent to approximately 5% of the capacity of the 80 MW district heating plant. To burn waste and recover the heat at the site to provide so little of the need is not warranted as the cost and maintenance of the separate boiler system would be uneconomical. However if a larger heat and material recovery plant, such as was proposed for the Region of Peel was located in the vicinity, then the residue material from a larger collection area could provide a significant amount of heat to the City Centre.

## IX. SOLAR ENERGY

### 1. Introduction

Although the orientation of planned roads in the City Centre is not ideal for passive solar gain (see Section X 2.1 orientation) there is still opportunity to utilize the sun through active collectors. Large areas of flat roof will be available for the placement of collectors that could be correctly oriented in diagonal patterns. (Figure 12 ). In a limited study area of parcels 6, 7, 8, 10, 11, & 12 it was determined that up to 74,475 $m^2$ of roof area could be available.




| STUDY AREA | MAX. ROOF AREA AVAILABLE FOR SOLAR COLLECTOR USE ($m^2$) |
|---|---|
| 6 | 9,950 |
| 7 | 9,500 |
| 8 | 15,950 |
| 10 | 12,675 |
| 11 | 14,150 |
| 12 | 12,250 |
| | 74,475 TOTAL AREA |

ROOF AREA DESIGNATED FOR SOLAR COLLECTOR USE

Figure 12.

## 2. Solar Collector Potential

### 2.1. Factors

Roof area available in study parcels = 74,475 $m^2$

Ratio of collector to roof area = 0.4

Energy from collectors = 1897 $MJ/m^2$

Cost of collectors = \$630/m2

Total building floor area of parcels 6, 7, 8. 10, 11, & 12 = 455,722 $m^2$

Total building floor area for all parcels = 2,428,911 $m^2$

Total heating energy consumption = 751,688 GJ

### 2.2 Calculations

Total collector area for parcels 6, 7, 8, 10, 11, & 12

$$74{,}475 \times 0.4 = 29{,}790 \text{ m}^2$$

Collector Energy Potential

$$29{,}790 \text{ m}^2 \times 1897 \text{ MJ/m}^2 = 56{,}511{,}630 \text{ MJ}$$

Total Solar Potential for Mississauga City Centre

$$56{,}511.63 \text{ GJ} \times \frac{2{,}428{,}911}{455{,}722} = 301{,}196 \text{ GJ}$$

(40% of 751,688 GJ)

Cost of Solar System

158,775 m2 of collector @ \$630.00 $m^2$ = \$100,000,000.

### 2.3 Conclusion:

The non polluting, environmental, and zero fuel cost aspects of solar energy are attractive. The current costs for the system are prohibitive. However, in the future, improvements in the economics and reliability of the system may make it a viable retrofit option to supplement either an individual heating system or a central system.

## X. EFFECTS OF ALTERNATE BUILDING FORM ORIENTATION, GLASS AREA ETC. ON ENERGY CONSUMPTION.

### 1. Introduction

The energy saving assessment of the various building strategies results from computerized annual energy studies using climate-specific data from Toronto International Airport weather tapes that give hourly information appropriate for the City Centre Area.

The building function and program selected for testing was the commercial office building as it will constitute the largest built element in the completed City Centre.

The base case building design standards are those developed in Section III of the study and incorporating tinted glazing.

The simulation results that follow are for a 25,833 $m^2$ office building which is a typical office space increment in the Mississauga City Centre Area. The heating and cooling system energy consumption for the 12 storey base case building is 304 $MJ/m^2$/year with a total energy consumption of 541 $MJ/m^2$/year.

### 2. Alternatives tested:

#### 2.1 Orientation:

Existing and proposed street orientations for the bulk of the City Centre Area are almost 45° off the four cardinal directions. The test simulations

5. and 8. indicate that orientation need not be a factor stressed in planning as the savings are minimal or non existent. See Figures 14 & 15.

In general a rigid adherence to the four cardinal directions would be awkward and create building to street relationships that would be a major departure from the norm. However, certain building forms such as a square tower, and particular parcels of land with low floor area to land ratios could lend themselves to the employment of orientation strategies. N.R.C.C. document No. 16574 suggests that buildings with low energy requirements, such as low-rise apartment buildings can reasonably take advantage of heat gain criterion for the orientation of glazing. Parcels 1, 2, and 3 by their shape, relatively low density, and residential designation have potential for orientation for solar gain.

2.2 Glazing:

The test simulations 1., 2., and 9. demonstrate the variations in energy consumption that result from the use of double glazing (1.) as opposed to single glazing (9.) and varied glazing areas. (1. @ 35%, 2. @ 40%) Changing from single glazing to double glazing will result in a 32% savings in heating and cooling system energy use and an overall savings of 20% in total energy consumption. The potential for considerable energy savings through the use of double glazing is a clearly observed fact and is now generally accepted as a building industry standard. See Figures 13 & 15.

The flexibility in glazing area variations is not as great as first thought. The maximum glazing area is established by the N.R.C.C. criterion of 40% of the floor to floor wall area. The lower limit is one established by the Building Owners and Managers Association (BOMA). The BOMA glazing

criterion is one based on the maximization of leasable floor area. In essence if 50% or more of the floor to ceiling height of an exterior wall is glass then for the sake of floor area calculations the glazing line may be used rather than the interior surface of the solid wall. On a large building this rather minor dimensional difference can add up to a significant leasable area and building income. For the base case building dimensions a 35% glazing area was determined to be the minimum area that would conform to the BOMA standard. The increase in glazing area from 35% to 40% would produce nearly a 5% increase in the heating and cooling system energy use and nearly 3% more in total energy use. It would seem in this instance that the NRCC glazing area criterion is not an onerous one and not in a conflict with industry standards. In fact the installed cost of a square metre of glazed wall is nearly double that of an equivalent area of solid wall. The cost effectiveness of reducing glass area is one of immediate cost saving in both construction and energy consumption.

## 2.3 Building Form:

To assess the effect of form on energy consumption the following building forms were investigated:

1. Oblong plan (61.0 m x 30.5 m), 12 floors as in the base case simulation 1. Figure 13.

| | |
|---|---|
| roof area | 1860.5 |
| wall area (unglazed) | 5224.3 |
| glazing | 2813.0 |
| total area of envelope | 9897.9m$^2$ |

2. Square plan (30.5 m x 30.5 m), 24 floors as in simulation 6. Figure 14.

| | |
|---|---|
| roof area | 930.3 |
| wall area (unglazed) | 6965.7 |
| glazing | 3750.8 |
| total | 11,646.8 m$^2$ |

3. Square plan (52.7 m x 52.7 m), 8 floors as in simulation 7. Figure 15.

| | |
|---|---|
| roof area | 2777.3 |
| wall area (unglazed) | 4011.9 |
| glazing | 2160.3 |
| total | 8,949.5 $m^2$ least building envelope |

The rectangular building form generating the least envelope is one that for constants for gross floor area and floor to floor height, occurs when plan is square and when its height is one-half of its base.

To determine the least building envelope the following equations from ASHRAE Journal,March 1980 article Carl H. Jordan "Building Envelope Studies" was used.

$$A_F = X^2n = X^2 \left(\frac{X}{2h}\right) = \frac{X^3}{2h} \qquad X = \sqrt[3]{2hA_F}$$

and

$$A_F = X^2n = (2hn)^2 = 4h^2n^3 \qquad n = \sqrt[3]{A_F/4h^2}$$

where
- $h$ = floor-to-floor height, a constant
- $A_F$= gross floor area, a constant
- $X$ = length of base, so that $X^2$ equals the area of one floor
- $n$ = number of floors

The results of the simulations clearly indicate that if the envelope is reduced then so is the energy consumption. The 24 floor slender tower in simulation 6. would require 22% more energy than the base case for heating and cooling whereas the 8 floor least envelope building could effect an energy savings of some 13% over the base case for heating and cooling. The total energy consumption for the 24 floor tower would be 12 + % greater than the base case whereas the 8 floor building would save 8+%.

As was the case for glazing the energy savings derived from the form that requires the least envelope is gained at a savings in construction costs, so that if all other considerations were equal, it should be seriously considered.

## 2.4 Storage Tanks and Heat Pumps

Of all the options tested the use of Heat Pumps and Storage tanks seem to offer the greatest energy saving opportunities. Saving in heating and cooling energy of up to 17% can be achieved with heat pumps and up to 38% if used in conjunction with storage tanks. Overall energy savings would be in the order of 10% and 21% respectively. Figures 13 & 14.

## 2.5 Relative Importance of Infiltration Due to Wind and Infiltration Due to the Stack Effect in Tall Buildings

The quantity of detailing and construction of the building skin can have a demonstrable effect on the energy consumption characteristics of building. The flow of air through the skin is affected by the external wind conditions and the internal conditions that cause a stack effect in a building. Figure 16.

An hour-by-hour computer simulation was run for the whole year utilizing the Malton weather tape and infiltration algorithms developed by N.R.C.C. (C.Y. Shaw, G.T. Tamura, The Calculation of Air Infiltration Caused by Wind and Stack Action for Tall Buildings, A.S.H.R.A.E. Transactions, Vol. 83, Part 2).

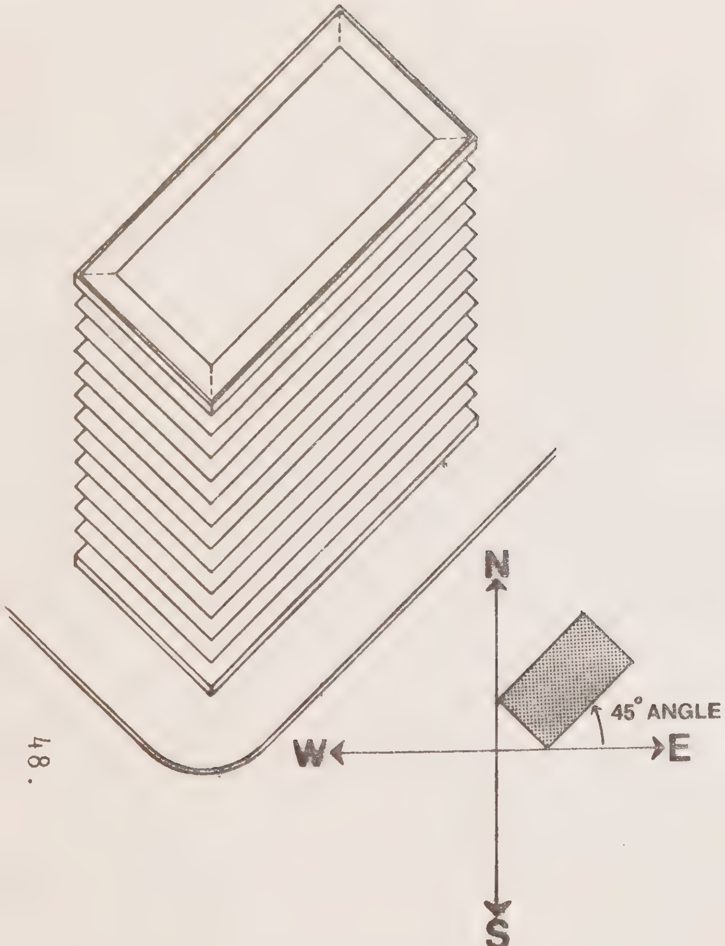
| Height of Building | Infiltration Energy Due To Wind Effect | Stack Effect |
|---|---|---|
| 12 floors | 18.84% | 81.16% |
| 6 floors | 21.34% | 78.66% |
| 4 floors | 22.84% | 77.16% |

The above indicates that the annual heating energy consumption due to wind is about 1/5 of the total infiltration energy. Measures to reduce local wind velocities would have an effect only on the portion of the infiltration due to wind. This observation may be useful in assessing the potential of wind breaks, massing of buildings and similar measures.

At the individual building level the simulations 10. and 11. indicate the effects. In simulation 10. the base case building with a loose skin (high infiltration) would require nearly 10% more energy for heating and cooling and 5+% more for total energy. The tight skin (low infiltration) building in simulation 11. has a 6+% reduced requirement for heating and cooling energy with a total energy savings of 3½%. The quantitative definition for skin tightness is taken from C. Y. Shaw, G. T. Tamura reference previous page.

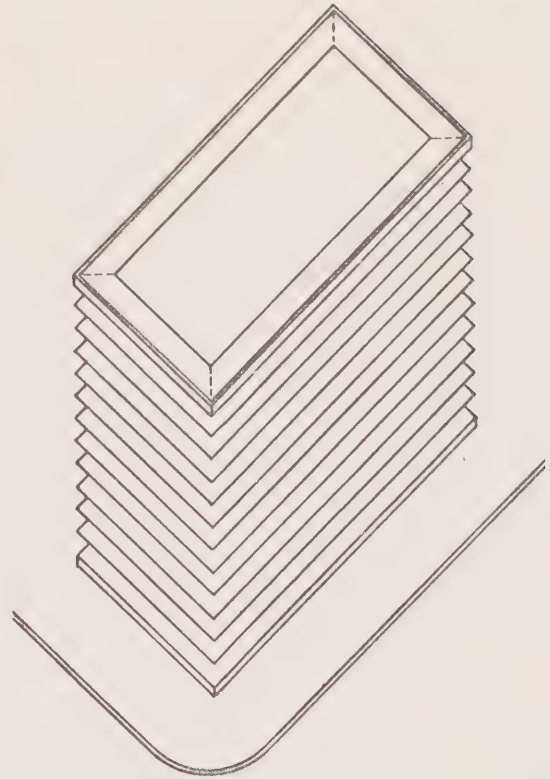
## 2.6 Insulation

Simulation 12 demonstrates the impact of poor insulation on the energy consumption characteristics of a building. The poor insulation standard would require nearly 11% more energy for heating and cooling and .6% more for total energy. The extra cost involved in raising the wall insulation from R = 1 to R = 2.1 would be recovered in approximately three years through the energy saving achieved. See Figure 16.



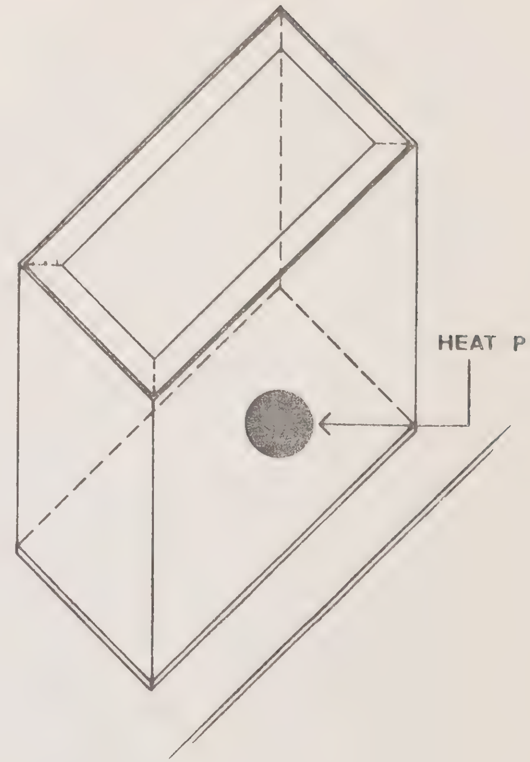

1. Base Case
   Oblong plan (61.0 m x 30.5 m) 12 fl.
   Glass - 35% of wall area.
   Wall orientation is 45% off the four cardinal directions

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| 100 | 100.0 |



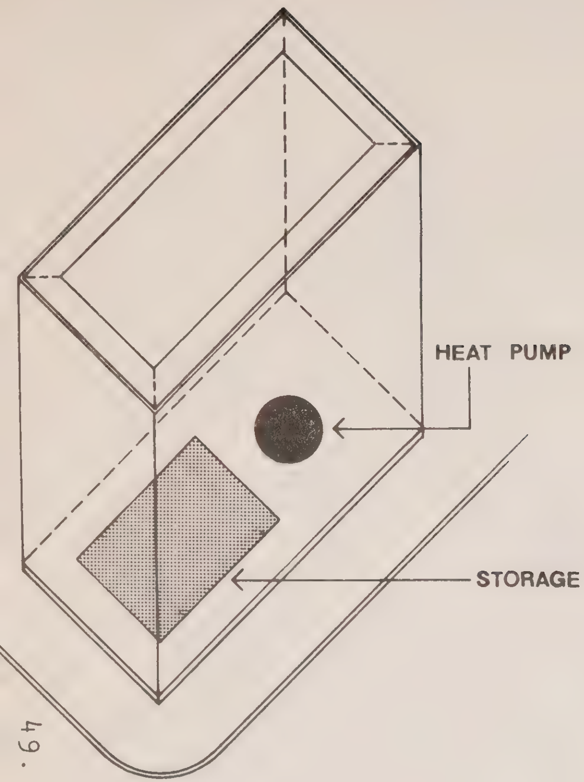
2. Base Case
   Glass - 40% of wall area

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| 104.8 | 102.7 |

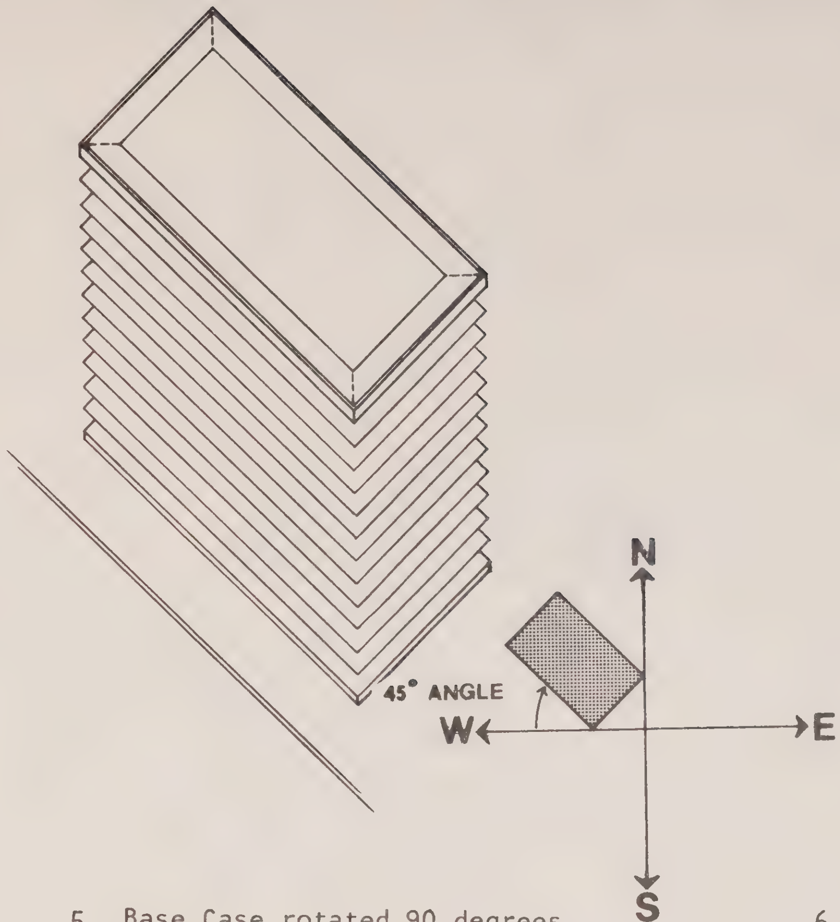



3. Base Case
   with Heat Pump

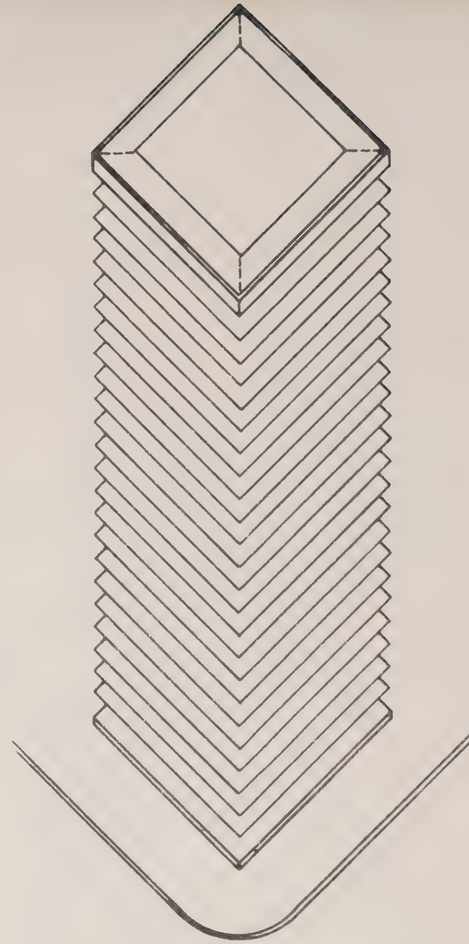
| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| 82.4 | 90.1 |




4. Base Case
with Storage tanks and Heat Pump



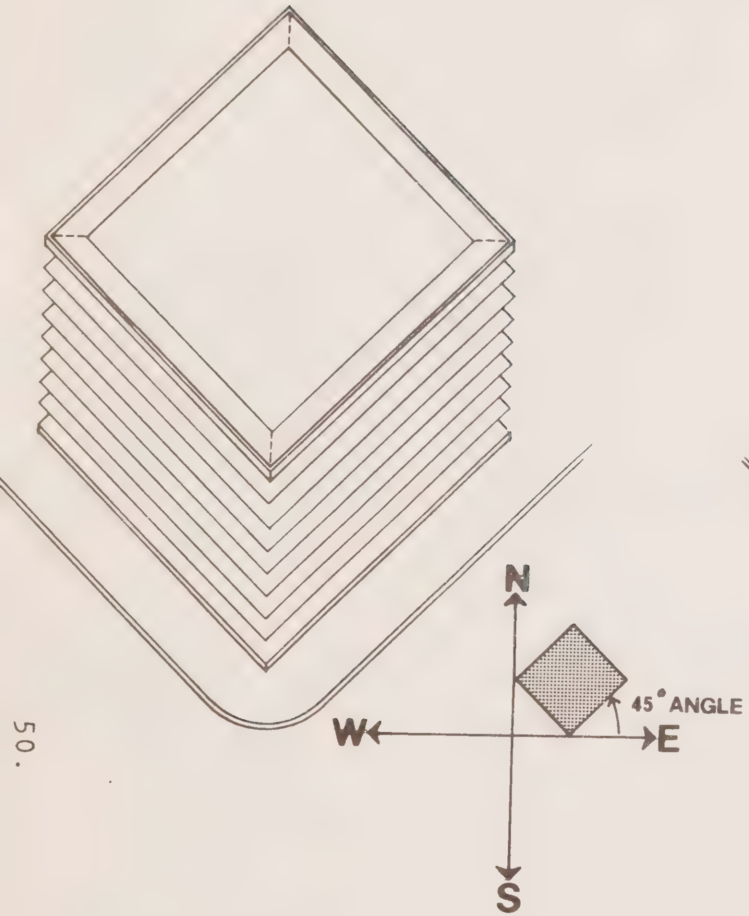

5. Base Case rotated 90 degrees



6. Square plan (30.5 m x 30.5 m, 24 fl.
Glass - 35% of wall area

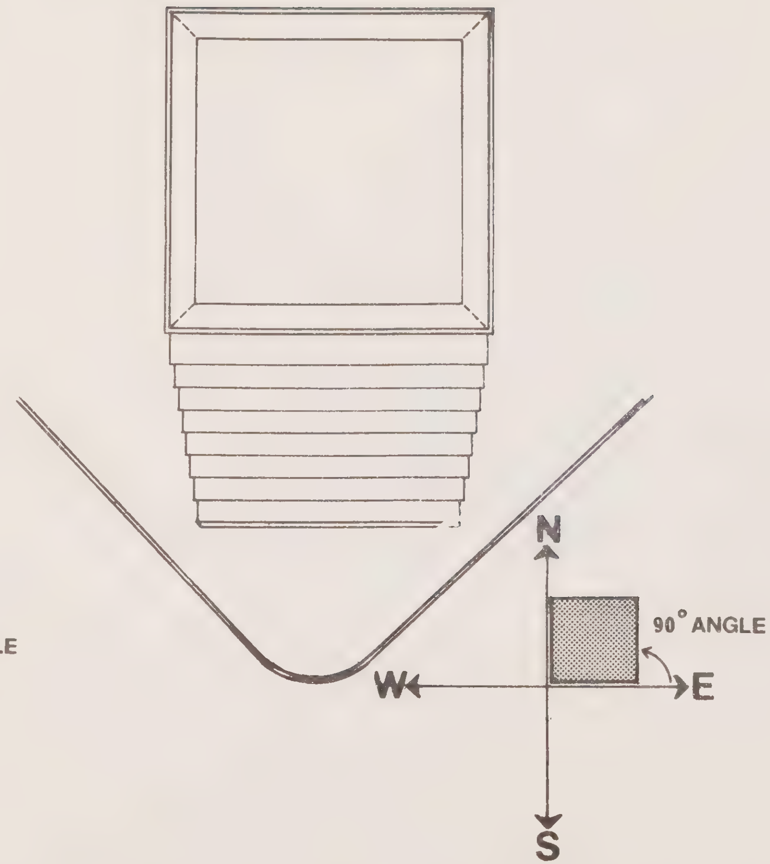
| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case | Heating & Cooling % of Base Case | Total Energy % of Base Case | Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|---|---|---|---|
| 61.3 | 78.3 | 100.0 | 100.0 | 122.4 | 112.6 |

Figure 14.



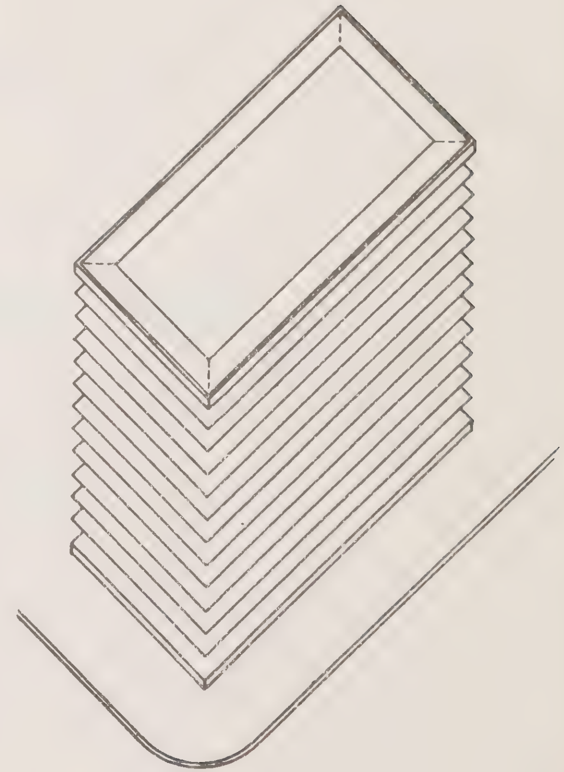

7. Square plan (52.7 m x 52.7 m), 8 fl.
   Glass - 35% of wall area
   *minimum building envelope ie. least total area of wall and roof.

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| 84.7 | 91.4 |



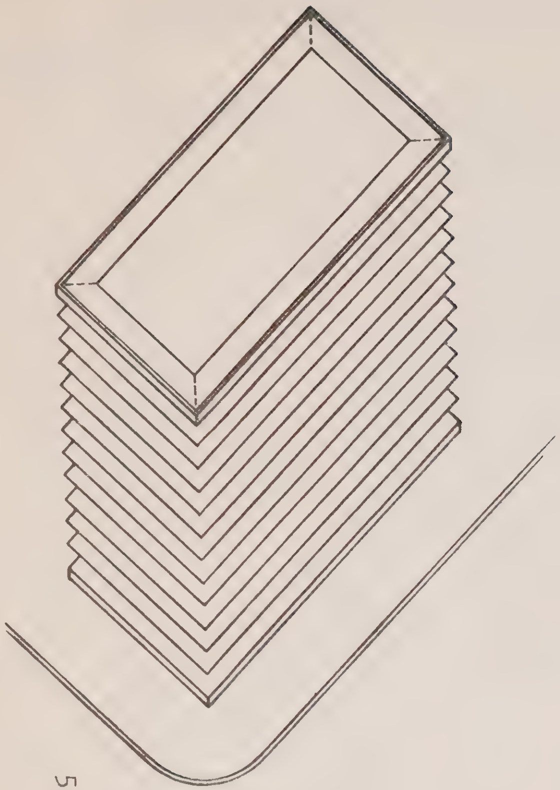

8. Square plan (52.7 m x 52.7 m), 8 fl.
   Glass - 35% of wall area
   Rotated 45 degrees

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| [illegible] | [illegible] |



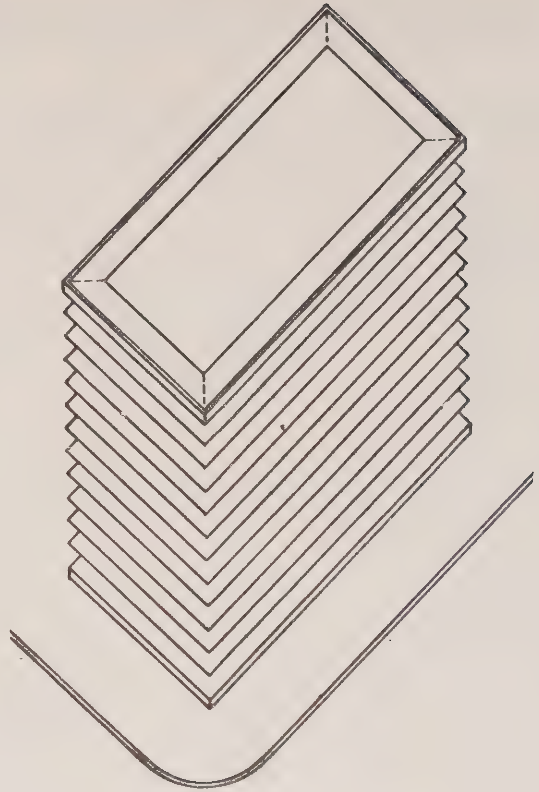
9. Base Case, Single glazed

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| [illegible] | [illegible] |



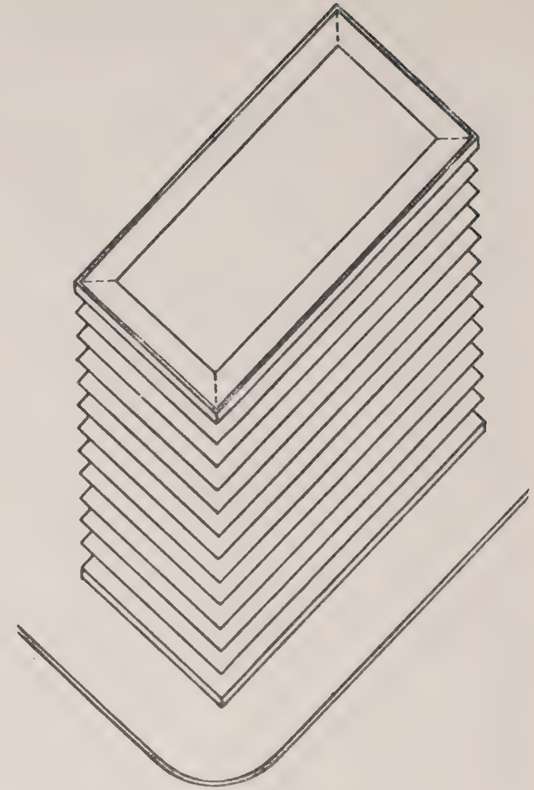
10. Base Case, Loose skin (high infiltration)

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| 109.6 | 105.4 |



11. Base Case, Tight skin (low infiltration)

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| 93.6 | 96.4 |



12. Base Case, Poor wall insulation (R = 1)

| Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|
| 110.7 | 106.0 |

Figure 16.

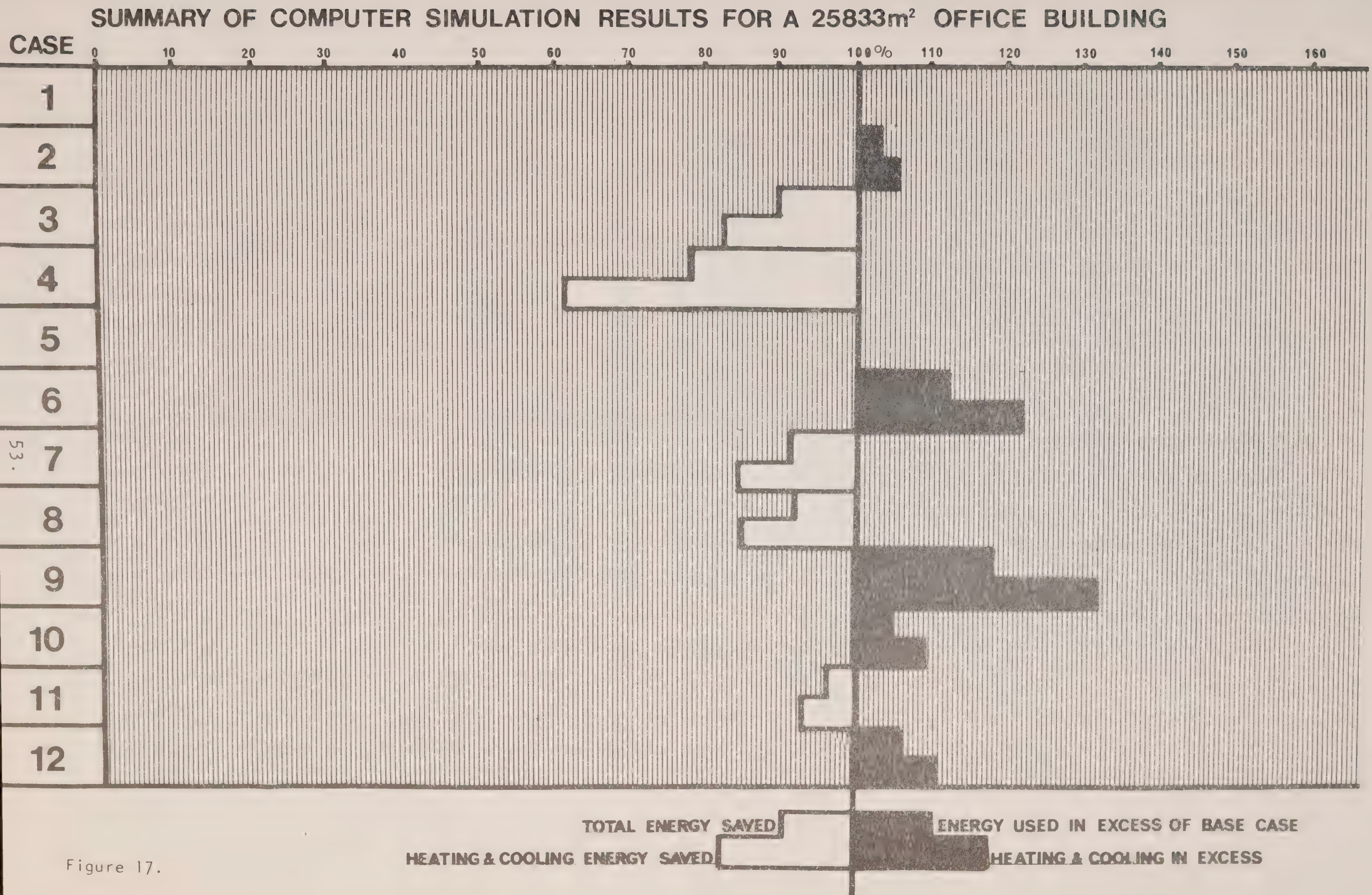
## 3.0 Summary of Computer Simulation Results for a 25,833 $m^2$ Office Building

| | Heating & Cooling System Energy % of Base Case | Total Energy % of Base Case |
|---|---|---|
| 1. Base Case<br>Oblong plan (61.0 m x 30.5 m)<br>Glass - 35% of wall area.<br>Wall orientation is 45% off the four cardinal directions | 100 | 100.0 |
| 2. Base Case<br>Glass - 40% of wall area | 104.8 | 102.7 |
| 3. Base Case with Heat Pump | 82.4 | 90.1 |
| 4. Base Case with storage tanks and Heat Pump | 61.3 | 78.3 |
| 5. Base Case rotated 90 degrees | 100.00 | 100.0 |
| 6. Square plan (30.5 m x 30.5 m), 24 floors<br>Glass - 35% of wall area | 122.4 | 112.6 |
| 7. Square plan (52.7 m x 52.7), 8 floors<br>(min. envelope) Glass - 35% of wall area. | 84.7 | 91.4 |
| 8. Square plan (52.7 m x 52.7 m), 8 floors<br>(min. envelope) Glass - 35% of wall area.<br>Rotated 45 degrees | 84.6 | 91.3 |
| 9. Base Case, Single glazed | 132.4 | 118.2 |
| 10. Base Case, Loose skin (high infiltration) | 109.6 | 105.4 |
| 11. Base Case, Tight skin (low infiltration) | 93.6 | 96.4 |
| 12. Base Case, Poor wall insulation (R = 1) | 110.7 | 106.0 |

Base case heating and cooling system energy consumption is 304 $MJ/m^2/year$

Base case total energy consumption is 541 $MJ/m^2/year$

NOTE: See Figure 17 for graph of above results.



SUMMARY OF COMPUTER SIMULATION RESULTS FOR A 25833m² OFFICE BUILDING
CASE
0
10
20
30
40
50
60
70
80
90
100%
110
120
130
140
150
160
1
2
3
4
5
6
7
8
9
10
11
12
TOTAL ENERGY SAVED
ENERGY USED IN EXCESS OF BASE CASE
HEATING & COOLING ENERGY SAVED
HEATING & COOLING IN EXCESS


Figure 17.

## XI. MICROCLIMATE CONSIDERATIONS

### 1. Introduction

Microclimate is the climate of a small area as it is affected by immediate surroundings in the form of topography, vegetation, and man-made structures. It is possible for planners and architects to manipulate microclimate through form, massing, and studied placement of structures and landscape features. Before microclimate can be manipulated the macroclimate - the normal range of temperature, humidity, sunlight, winds, and precipitation in a large region - must be understood. Little can be done to alter or control this macroclimate.

### 2. Macroclimatic Data For Mississauga City Centre - Based on Data at Toronto International Airport (Malton) for Minimum 20 Year Period.

2.1 Prevailing Winds: mostly W, followed by SW and S.

2.2 Strongest Winter Winds: (19 mph. or more): SW, WSW, W, WNW, NNW, and N. are all important

- blow 3 hours daily average during winter months,
- these wind directions account for 86% of all winter strong winds.

2.3 Wind Chill Factor

- discomfort every third day during winter months on average (based on maximum daily temperature not exceeding 20$^{o}$ F (-6.5$^{o}$C) )
- discomfort also occurs when wind speed is greater than 5 mph. (8 kph.) and dry bulb temperature is below 15$^{o}$F (-9.5$^{o}$C).

  Winds responsible blow from predominantly N and NNW.
- the discomfort factors are subjective as the people involved vary from the young to the elderly and infirm.

2.4 Winds with Blowing Snow: mostly N and NW.

2.5 Strongest Summer Winds for Ventilation:
(based on 80°F (26.75°C) dry bulb)
- SSE, S, SW, WSW and W. The WSW and W winds dominates summer winds.

2.6 Mean Daily Maximum Temperature (based on 1941 - 1970 data)

| | January | July | Year Average |
|---|---|---|---|
| i) Airport: | -3°C | 27°C | 12.5°C |
| ii) Clarkson: | 0°C | 28°C | 13°C |

Mean Daily Minimum Temperature

| | January | July | Year Average |
|---|---|---|---|
| i) Airport: | -9.5°C | 14°C | 2°C |
| ii) Clarkson: | -8°C | 15.5°C | 4°C |

2.7 Number of Days with Frost i) Airport: 154
ii) Clarkson: 121

2.8 Number of Days with Snow: i) Airport: 45 January maximum
ii) Clarkson: 22 January maximum

Number of Days with Total Precipitation:
i) Airport: 134
ii) Clarkson: 91

See Appendix <u>V111</u> for macro-climate information re
- Wind roses.
- Airport wind data.
- Sun chart

## 3. Winds Affecting The Microclimate

Within the local area of the Mississauga City Centre it has been ascertained that prevailing summer winds are primarily from the southeast, south and southwest, strongest winter winds emanate from west, northwest, and north, with blowing snow mostly from the northwest.

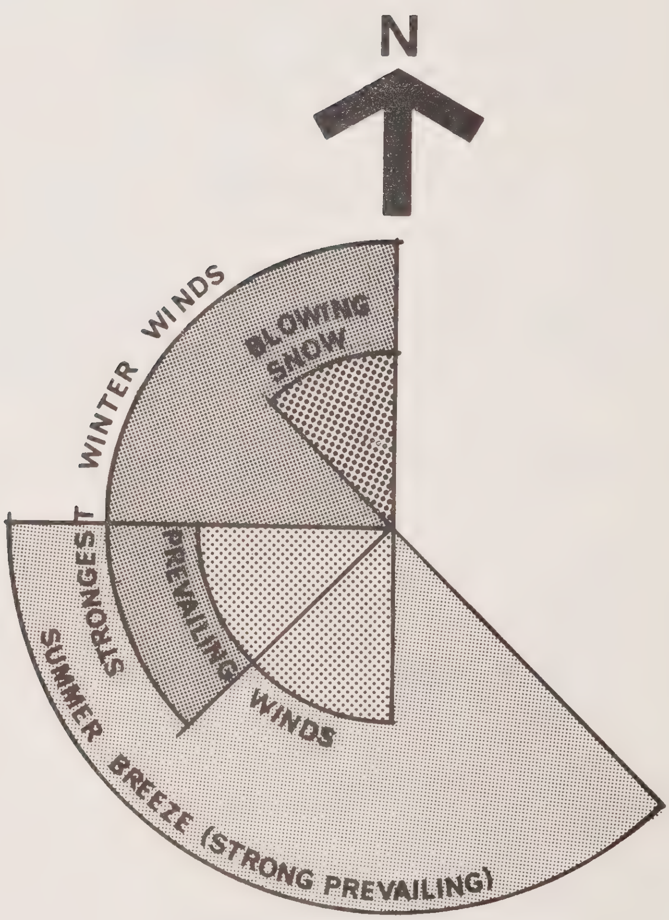



Figure 18.

4. Localized Modification Of Microclimate By Building Masses and By Non-Building Forms.

(For detail and diagrams, see Appendix 1X )

Wind, and consequently snow drifting, conditions are greatly affected at a local level by the following factors:

- Height of buildings
- Length of buildings
- Configuration of buildings
  - shape
  - podiums
  - stepping
  - arcades
  - openings
  - recesses
  - juxtaposition of building shapes or massings.
  - proximity of buildings
  - location and massing of trees, shrubs, walls, canopies, screens

In addition, placement, orientation, massing, and height of buildings or non-building forms can affect exposure to sun or shadow.

Manipulation of wind and sun conditions at the micro-level will greatly influence pedestrian comfort, pedestrian usage, landscape viability, traffic pollution, distribution, location and extent of snow drifting, and can make an important contribution in terms of potential energy conservation through orientation, and massing to optimize preferred solar exposures or to provide shielding.

5. Effects Of Development Controls On Microclimate

A critique of proposed development parcels in respect of building height limitations and site coverage is shown in Schedules 4, 5, and 6. (Figures 19, 20, 21).

## Schedule 4
## Development Parcels

## Schedule 5
## Building Height Limitations

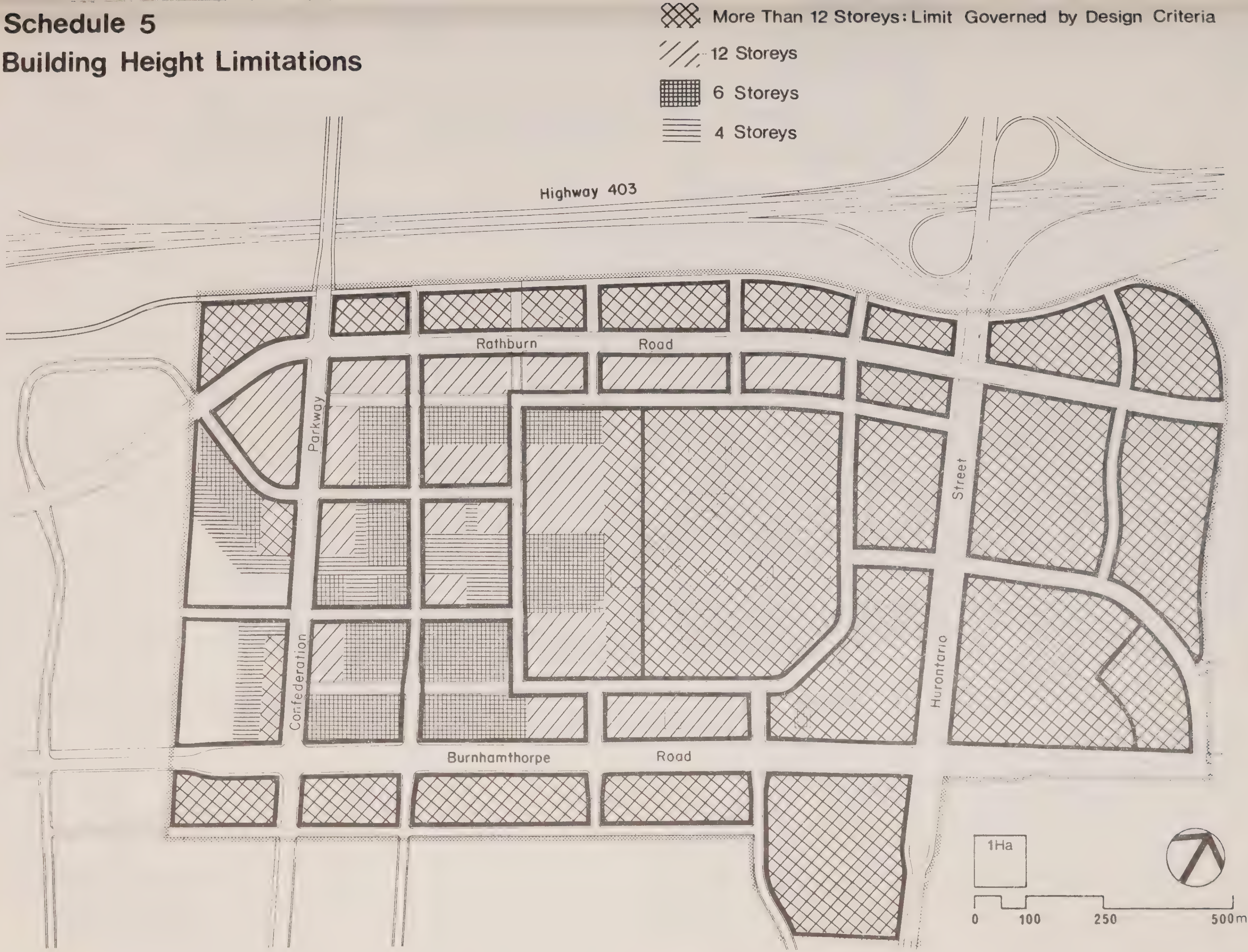
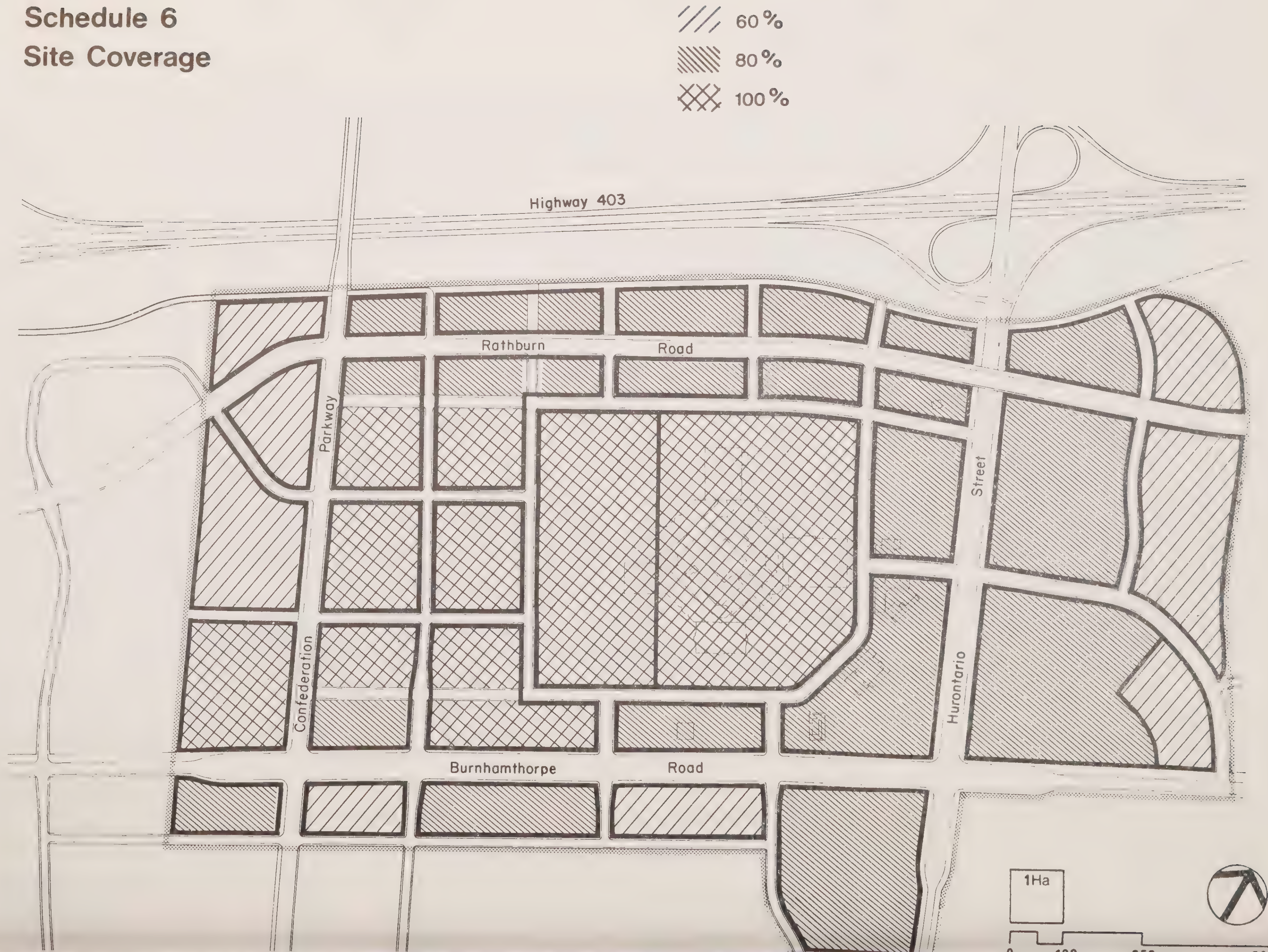



Figure 20.

# Schedule 6
## Site Coverage

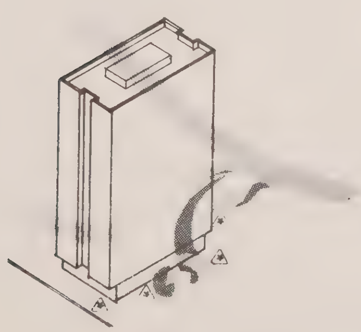


## 5.1 Positive Features

- Development parcels 1, 5, 9, 13, 18, 20, 21, and 22 as shown in Figure 19 are allowed to contain building in excess of 12 storeys. (Figure 20) Tall buildings in these areas will reduce wind flow and shelter the central part of the City Centre from winds emanating from the north through west quadrant.
- Development parcels 3 and 4 contain two areas where buildings in excess of 12 storeys are allowed. If both of these areas are built to their maximum site coverage as shown in Figure 21, this will assist in minimizing the adverse effects of west and southwest winds on the City Centre during the winter months.
- The development controls which govern the tall buildings on the south side of the site have been selected to permit summertime southerly wind flows to reach the City Centre. This has been achieved by alternating the site coverage between 60% and 80% on development parcels 24, 25, 26 and 27; all of which are allowed to contain buildings in excess of 12 storeys.

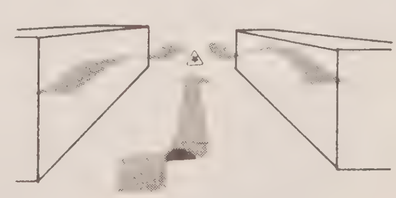
## 5.2 Negative Features

- In some areas, such as parcel 15, building setbacks have not been required even though buildings in excess of 12 storeys are adjacent to open pedestrian areas. Northwesterly winds will interact with tall buildings adjacent to open pedestrian areas to create uncomfortable pedestrian level wind conditions. Fig. 2.1 (a).
- The north-south pedestrian traffic routes are aligned with some of the strong northwesterly winter winds, while the east-west pedestrian routes are aligned with the prevailing southwest winds. Fig. 2.3(a)



a) This effect is magnified as building height increases

2.1



Wind can also be tunneled by relatively low buildings

2.3

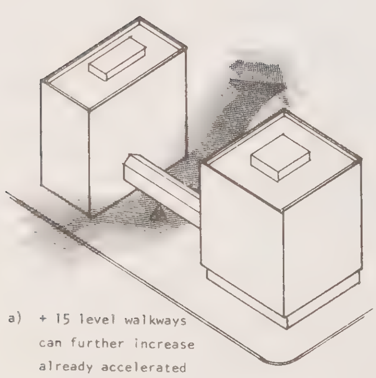
- Landscaping placed at the north and west ends of the pedestrian walkways would minimize the adverse pedestrian level winds. Landscaping groups placed at intervals along the walkways will prevent a wind canyon effect from gradually building up. Figure 2.15(a) & (b).

a) Deciduous trees:- Often does not provide ground level protection - only provide protection during the summer months - are good for forming canopies to reduce downward wind flows.

b) Underplanting will assist in providing ground level protection

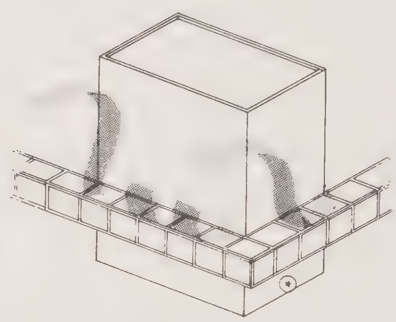
- Buildings on the south side of all plazas should be limited in height and/or setback to provide the maximum sun conditions during the period 12 - 2 pm, which is the time of maximum usage of the plazas. The angles for this time of day are given in Appendix V111

- Pedestrian bridges should be kept to one storey in height and their optimum location and cross-section should be selected by scale model studies to prevent increased pedestrian level winds. Fig.2.2(a), 2.7(b), 2.9(



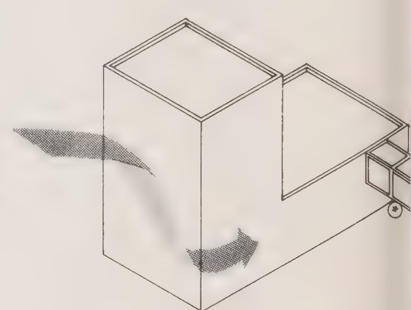
a) + 15 level walkways can further increase already accelerated wind flows.

2.2



b) +15 level walkways can be used as canopies

2.7

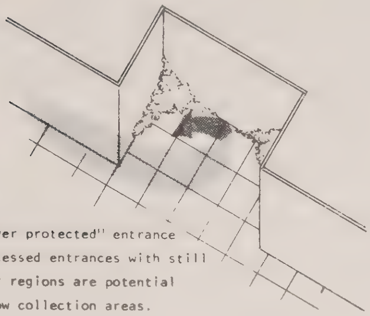


c) +15 walkways should be located away from increased corner flows

2.9

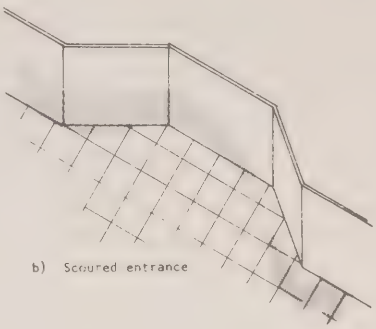
- Jogs, setbacks and protrusions should be incorporated into the faces of the buildings fronting onto the pedestrian walkways to assist in retarding the windflows along the walkways. The snow accumulations resulting from this type of design must be accounted for and located in non-critical areas.

- Northwesterly winds are associated with blowing snow and therefore recessed entrances off the north-south pedestrian route may experience problematic snowdrifts. Fig.2.11(a).



a) "Over protected" entrance
Recessed entrances with still air regions are potential snow collection areas.

2.11



b) Scoured entrance

2.11

- The walkways are in a grid system and are open to the major traffic routes surrounding the entire area. This will permit pollutants, expelled from automobiles, to be carried by the winds into the pedestrian system and pedestrian plazas. A scale model study of the wind flows surrounding the area would suggest building forms to alleviate this potentially severe problem.

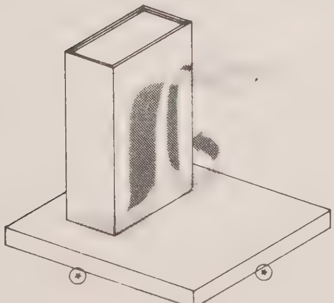
## 5.3 Desirable Features

The following comments are referenced to figures in Appendix IX "Localized Modification of Microclimate by Various Building Masses", Appendix X "Climatological Acceptance Criteria For Pedestrian Activities", and Appendix XI "Seasonal Comfort Criteria Assessment".

- Buildings adjacent to pedestrian traffic area should be no higher than four storeys. Fig. 2.7 (c)

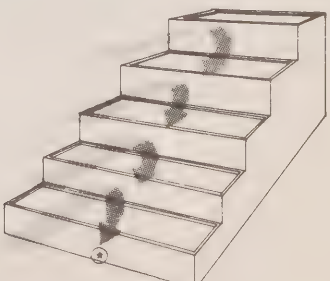
- Buildings adjacent to pedestrian lounging areas should be no higher than two storeys. Fig.2.7 (c).

- The tall buildings at the north and west ends of the pedestrian walkways should be carefully designed to prevent wind canyons being created along the walkways. Possible design alternatives include a podium setback, or stepped north and west faces as shown in Fig. 2.7 (c) and 2.8 (a).



c) Non-pedestrian podiums provide comfortable walkways around tall buildings

2.7



a) Stepped buildings will gradually break up approaching wind flows

2.8

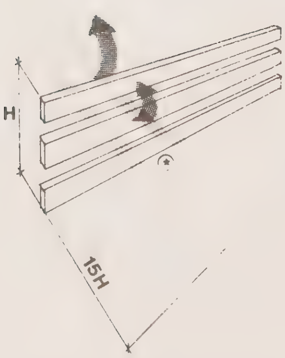
- Pedestrian walkways should, wherever traffic patterns permit, not continue in straight uninterrrupted lines. Wind cannot easily flow down walkways which are not in a straight line or have large obstructions placed in them.

- Deciduous trees placed on the north side of the plazas will provide shade from the sun and wind in the summertime but will allow solar heating of the buildings with south facing windows.

- Coniferous trees can be used on the south side of the plazas without affecting the solar heat gain of the building on the north side of the plazas. Walkways for the use in the winter time should therefore be planned to be on the south side of plazas where the coniferous landscaping will provide comfortable conditions.

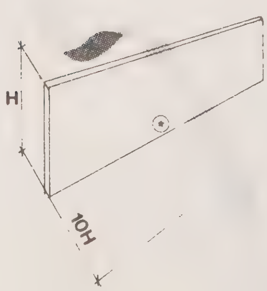
- The wind should be kept to low levels within the plazas to prevent gusting of the wind and the subsequent raising of dust and other debris. Spaced tree plantings can achieve this. The wind speed must not be so low that pollutants or snow drifting become problematic. Again, scale model studies can determine the optimum landscaping to meet these strict requirements

- Plazas which are windy, either because of improperly designed adjacent buildings or a restriction on the placement of landscaping (e.g. underground parking imposing load limitations) can be partially improved by local wind screens. Such screens, which are illustrated in Figure 2.14 a-d, only provide local protection and can be thought of as extending the usage of local areas and not the entire plazas.



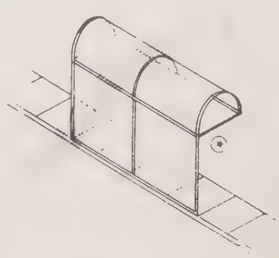

a) A 50% porous screen produces a reduced velocity area for 15H...

2.14




b) .... A solid fence for 10H

2.14



c) Partially enclosed walkways must be oriented considering the prevailing wind directions........... ...

2.14

d) ....Also localized w shelters

2.14

- East and west facing arcades can provide beneficial sun shading during the summer (particularly) west facing as air temperature are higher when west facing arcades are sunlit), while allowing sun penetration during the summer. Scale model and heliodon (sun simulator) studies can optimize these conditions.

- Unwanted glare from mirror glazing in plazas and walkways should be checked, possibly using a scale model and heliodon (sun simulator) to ensure glare definitely does not occur during periods of maximum usage of the plazas and walkways (8:00 am to 9: am; 12 noon to 2:00 pm; 4:00 pm to 6:00 pm ). Low intensity reflections in wintertime can provide beneficial light to shade south sides of walkways or plazas.
- Measures should be taken to avoid reflected heat from glazing adversely affecting landcaping by overexposing the north side of plants to excess sunlight.

## 6. Energy Conservation

Energy losses from air infiltration occur as a result of the pressure differences created across the outer walls of a building by wind flows. The losses due to air infiltration can be reduced by changing the pressure differences across outer walls by modifying the wind flows around buildings. The most significant methods used to change the wind flows are to: i) arrange the buildings so that they provide windscreens for each other and ii) arrange the landscaping to reduce the wind infiltration on the first storey of buildings.

It is conceivable that energy savings could be achieved for the Mississauga City Centre by arranging the buildings to screen each other and this has been done to a certain extent with the north and south development parcels. The proposed tall and relatively closely spaced buildings to the north will assist in reducing cold northerly winds from reaching the City Centre and the open spaced buildings to the south allow cooling breezes during the summer time. It would be possible, using a wind tunnel model, to determine the pressure profiles around the buildings on the north side of the site and to determine the energy savings possible by rearranging the buildings to allow them to shelter each other. There are no precedents of previous similar studies available to determine the possible outcome of such a study. The central and lower buildings would not benefit as much from such a study as the buildings are often arranged closely to each

other leaving little room for variation.

If landscaping is planned in various areas it can be used beneficially to reduce the heat loss from the ground floor of a building. This is particularly true around areas of large infiltration, such as frequently opened doorways. Scale model studies, similar to those recommended to control the pedestrian level wind conditions, can be used to provide the optimum placement of landscaping elements.

## 7. Recommendations of Future Action

### Simulation Tests:

The optimum method for conducting model wind and snow simulation model tests on a development such as the Mississauga City Centre is to initially construct an overall scale model of the area. This should contain those buildings which presently exist on the site and also building masses to represent the building shapes required by the various development controls. As there are various options of building shapes that can be selected under the guidelines it is essential that the model be capable of rapid changes to determine the effects on the microclimate of the various building shapes. Our experience suggests a modelling clay (plasticene) massing model at a scale of approximately 1:400. The model should be constructed in sufficiently small sections to accommodate the test facility being used. The tests should be conducted using an open channel waterflume as the visualization of the wind flows, which is not possible with wind tunnel studies, is vital to ensure that the building designers fully appreciate the potential pedestrian level wind problem.

This model can be used to test whether each new proposed buildings will satisfy the pedestrian level wind guidelines and will not create undesirable snow accumulations.

## XII. TRANSPORTATION - POTENTIAL FOR ENERGY CONSERVATION

### 1. Introduction

There is no doubt that great potential exists for the introduction of policy and/or restraints which would provide significant conservation of energy,at the urban level, with respect to transportation. There is unlikely to be an area fraught with as many difficulties for conservation. Energy utilization in urban centres has three distinct and problematic characteristics -

1. increase in fuel consumption is related to population characteristics, high living standards, urban sprawl, increased reliance on motive transport.
2. the continued reliance on petroleum - based fuels is apparent in the forseeable future.
3. those fuels will continue to increase in price.

Similarly, measures to ensure conservation face several challenging problems -

1. many of the most effective measures are not available to the municipality - i.e. - fuel cost, vehicle cost, taxation, vehicle technology,
   and here it is necessary for provincial or federal government action.
2. conservation measures enacted must not be seen to deteriorate the quality of life in the urban structure.
3. methods employed to encourage or enforce conservation in transportation must not endanger the local economy, which is often geared, unfortunately, to ease of vehicular access for market, goods, and labour price.
4. many of the methods if used in combination or in tandem can be grossly counter-productive.
5. an ultimate dependence upon individual reaction and dedication - public acceptance and consciousness.

Short distance journeys of people and freight represent the major portion of vehicular movement in urban areas; nearly one half of this country's road transport fuel is accounted for in these same areas. Any measures employed to enforce conservation must be tested in regard to a publicly acceptable level of mobility and the maintenance of the urban living patterns inextricably linked to the demands of urban transport.

2. Transport Related Energy Conservation Measures

(See Appendix XII a.)

Energy conservation measures for transport must be directed at five basic elements;

1. the user - passenger or shipper
2. the operator
3. the vehicle
4. the transport infrastructure
5. land use arrangement of origins and destinations.

These measures must be directed at the following:

1. trip reduction
2. length of travel
3. maintenance of person trips while reducing vehicular trips.
4. efficiency of vehicle
5. alternate modes of movement.

3. Commentary on Potential Measures within Municipal Control

(See also Appendix XII c.)

3.1 Curfew
- a prohibition of user activities for certain hours
- concentration of activity times and consequently transport use.
- restricted hours of travel could result in congestion.
- possible adverse effects in economic sphere
- an extreme measure which should only be employed in recognition of a serious problem
- public will balk at the use of curfews.

3.2. <u>Driving Day Ban</u> - a designated day or voluntary choice by driver
- difficult to achieve continued support.

3.3. <u>Road Priority</u> (for High Occupancy Vehicles)
- special lanes, ramps, access points or high occupancy vehicles.
- banning certain vehicles from convenient routes and parking areas.

3.4. <u>Freight Consolidation</u>
- (see Appendix X11 d)
- multiple-user freight vehicles to reduce number of delivery trucks required in urban area.
- will reduce truck-trips and congestion.
- requires a licencing structure
- a "consolidation" terminal is required.
- messenger services and/or improved parcel service necessary.
- disruptive of conventional trading patterns.

3.5. <u>Truck Loading Zones</u>
- a few large truck shipments will generally be more efficient than many small shipments.
- each structure or preferably group of structures requires efficient loading/unloading facilities, guaranteed ease of access away from principal traffic areas
- will reduce road congestion.

3.6. <u>Truck Regulation</u>
- Zoning and building codes could encourage optimum location of large intercity truck terminals to reduce necessity for load transfer to less efficient smaller vehicles.
- legislation to prevent trucking during peak road - use periods.

3.7. <u>Ride Sharing Incentives</u>
- for rides to and from work
- can be encouraged by favoured parking areas or costs, special high speed traffic lanes

- employer provided vehicles possible.
- will reduce costs of parking infrastructure if effective.

3.8. Ride-on-Demand (Dial-a-Bus, Jitney)

- suitable where a combination of trips of nearby origins or destinations is possible especially within urban areas.
- fuel-efficient vehicles necessary

3.9. Improved Public Transit

- suitable in areas of high population density
- lower fares would increase the number of passengers
- increased service necessary best employed with other measures such as road priority, parking restriction
- a comprehensive external - to internal and internal - to internal service must be ensured through provision of extensive points for passenger interfaces.

3.10. Pedestrian Zones and Routes

(see Appendix X11e)(See City Centre Secondary Plan) Appendix X11f&g)

- the provision of continuous, pleasant, direct pedestrian routes among urban precincts can reduce reliance on vehicles.
- to be satisfactory such routes must provide a comprehensive, pleasant, safe network connecting all major activity nodes.
- weather protection and grade separations necessary
- vertical and horizontal discontinuity must be avoided.
- each development parcel must be encouraged to contain a variety of commercial facilities needed by users throughout the day.

- amenities such as signage, washrooms, seating areas - must be appropriately included.

3.11. <u>Bicycles</u>

- while use of bicycles is guaranteed to conserve fuels, a significant infra-structure for routes and security is necessary.
- a large portion of the population - seniors, mothers with small children, the infirm, etc. - cannot rely on bicycle transport.
- while some utility for conservation exists it is obvious that this can be seasonal at best, and depends greatly on weather conditions.

3.12. <u>Improved Traffic Management</u> (see Appendix XII d, Appendix XII h)

- a co-ordinated program of incentives, regulation, sharing, pedestrian routes.
- optimization of speed limits
- steady traffic flow through minimization of stops - signal co-ordination, flow control, one-way streets, ramp metering, congestion - control metering for core area.
- reserve lanes for High Occupancy Vehicles - taxis, car pools, buses,etc.

3.13. <u>Education</u>

- for traveller and operator
- information campaign and training activities directed at conservation practices which minimize inconvenience
- publicity of optimum speeds, special transit services, maintenance programs, and proper operating practices.
- a determined campaign to familiarize the populace with the serious nature of the energy problem and the potential of conservation.
- at all government levels and at employer level.

3.14. Parking Regulation
- banning or discouraging car entry to critical areas.
- parking changes or preferences which encourage fringe parking and public transit usage, pooling, etc.
- reduction of spaces available
- a negative effect can occur with respect to businesses.
- the existing policies in the area may prevent a comprehensive approach.

3.15. Land Use Planning (See Appendix XII d)
- land use patterns which encourage the integration of employment and residential areas, well served by transit.
- compact land use and mixed use zoning
- higher densities bring more users closer to the transportation system.
- optimization of numbers and locations of parking areas.
- simplification of street patterns.

4. Conclusion:

The application of any measures to improve energy conservation characteristics must only occur subsequent to a careful and thorough analysis of each proposed action taking into account the particular situation, all possible consequences and inter-relationships with all other measures. There must be a co-ordinated regulation of all activities to prevent adverse effects on other policy goals which may cause a net increase of consumption either as a result of conflict or inordinate infrastructure or support energy costs.

The physical layout of the Mississauga City Centre is relatively established in terms of land-use patterns and major internal road systems, and therefore the questions of more efficient land-use patterns from the standpoint of diminishing purely internal auto trips is somewhat hypothetical. In addition, many of the possible conservation methods are not discrete to the Centre but involve the entire region. Certainly no planning steps should be taken in or about the City Centre which would, in future, preclude introduction of any of these measures.

It is clear that little can be achieved in controlling supply and use of parking facilities for energy conservation purposes as long as spaces are provided freely across the site and without charge to office workers or the general public. In such a situation, drivers will rarely accept any control calling for voluntary action. While present policy and agreements may preclude measures in this regard, certainly consideration should be given at all stages to ensure that the imposition of controls will not be totally impossible if and when they may become an absolute necessity.

5. Recommendation

The following recommendations are representative of the types of measures most readily adopted consistent with existing policy goals and quality of current life style:

5.1. Encourage and enforce Guidelines for Pedestrian network as outlined in City Centre Secondary Plan. Hopefully, through careful co-ordination the pedestrian network will provide more direct and more pleasant movement between activity nodes than the vehicular traffic systems.

5.2. Formulate general strategies bearing on the amount and distribution of parking. These strategies should include as a minimum the following:

1. Car and vanpool operations involving employees should be encouraged by setting aside conveniently located parking areas for their exclusive use. Control of the use of such areas by the general public might not be too great a problem considering the hours at which office and store employees usually arrive. The problem of keeping out single-occupant cars driven by other employees is more difficult to deal with and might be solved only by internal administrative actions taken by the larger employers who have been assigned designated parking areas for their workers.

As an example of what is being done, the Ministry of Transportation and Communication has at its Downsview office complex about 170 close-in spaces reserved for cars with at least one passenger. Periodic inspections are made to ensure compliance. The Toronto Parking Authority has nearly 1000 reduced-rate spaces

in two lots near the Gardiner Expressway. Here the requirement is two passengers.

.2. Currently the tendency is to work with slightly lower parking ratios than have been used in the recent past (number of spaces per employee, per unit of floor area, etc.). As far as the general public is concerned, we may begin to see more effects on auto use brought about by increased application of computers and telephone devices for ordering merchandise, by a growing trend towards trip consolidation so that fewer journeys are made overall for discretionary trips, and by a movement towards greater use of public transit. It is recommended therefore that the parking ratios applied today not be considered fixed throughout time, and that the parking allowance for successive phases of construction be evaluated in the future in the light of such possibilities for socio-economic change having taken place.

.3. Setting aside certain areas for drivers of small energy-efficient cars is a difficult issue because of problems of defining exactly what is a small car. Nevertheless, it would be helpful if the desired-for move towards smaller vehicles be recognized by the allocation of some favourably located lots laid out with a somewhat smaller stall dimension. A problem here is that in some smaller cars the clearance for open doors has not diminished.

5.3. Preparation of a guideline for parking efficiencies and optimum parking layout with respect to energy efficiencies and requirement that all developers adhere to policy.

5.4. Study of Feasibility of Establishment of Trucking and Delivery Consolidation Terminals.

5.5. Ongoing Encouragement of Public Transit Operations.

.1. Obviously every encouragement should be given to transit operations in order that more and more employees and the public can be diverted away from the private auto. Present services into the City Centre terminate at Square One, a convenient location for most people going there today. As

the Centre grows physically, there should be provided a comprehensive external to internal and internal to internal service by extending the number of points at which passengers can be set down and picked up by transit vehicles as part of their scheduled operation. This would be similar to any current downtown operation.

.2. Points of entry/exit at the adjacent street system should be designed to permit transit vehicles to move as freely as possible. Special intersections or turning lanes should be considered as well as allowing buses to turn where other vehicles are prohibited from doing so. Methods of assigning priority to buses at signalized intersections have been under study for some years but have not been widely adopted because of certain practical difficulties.

.3. Continued extension of Mississauga Transit's very successful Bus Passenger Information System will be of benefit.

5.6 Conduct a Traffic Management Study for Mississauga City Centre and Immediate Surroundings to ensure ease of access, flow, minimization of congestion, etc.

5.7 Education Programmes and Promotion

It is important that the need to move towards energy conservation practices be advanced as much by private interests as by governments. While the issues in the transportation sector do not lend themselves to the same sort of rigorous control as is possible with the design and operation of structures and heating/cooling systems, it would be a worth-while contribution on the part of the developer if the issue of transportation energy conservation be kept constantly in front of the tenants, employees and the general public. In the case of employers moving to the City Centre, general assistance or advice could be given on ways of going about organizing car or vanpools. Special displays in areas of high pedestrian concentration could be used for disseminating information on transit operations serving the City Centre, and on the benefits of operating smaller cars and improving general driving habits. While we feel that bicycling can have only a marginal impact because of climatic and other

constraints, this mode should be included in all displays.

The developer should be encouraged to adopt a stance which recognizes the need for energy conservation in the transportation sector, and assists the general achievement of such objectives by taking certain actions in the planning and operation of the City Centre. Some of these steps will involve the municipality as well as tenants and their employees.

5.8 Encouragement of the inclusion of user-orientated service retail within each development parcel in order that internal traffic movement may be minimized.

## XIII. THE IMPLICATION OF TENURE ON ENERGY CONSUMPTION

### 1. Introduction

The assessment of the impact that the mode of tenure has on energy consumption is a nebulous area of investigation due to the paucity of reliable data for buildings of equal size, systems and uses with tenure as the only variable. It could be argued that if all buildings are equally well built, maintained and operated and all the occupants have energy conserving work habits then the method of tenure should have little or no effect on energy consumption from one building to another. However, conventional wisdom suggests that awareness of and action to reduce energy consumption improves directly with the proximity of the utility bills. In other words he who pays the bills turns out the lights. The clear implication being that energy savings that can be realized as money saved is a strong motivation to conserve. The extent of such savings derived from adopting energy conserving habits would vary with each category of tenure and would be influenced by a number of the following factors:

1. Options available for energy conservation that are available in the operation of the building, its systems and mode of use.
2. Range of options available to each group.
3. Incentives to conserve.
4. Deterrents.
5. Methods available to implement and control conservation programs.

### 2. Options for the Conservation of Energy Through Post-Construction Building Operations

2.1 Hire properly trained personnel that are familiar with how to operate equipment and distribution systems for optimum conservation of enrgy.

- To assure peak efficiency and economy of equipment operation.

2.2 Train maintenance and security personnel to control lighting by a predetermined schedule.

- To assure lights are on only when needed for a specific task.

2.3 Consider rescheduling of building operations in order to decrease peak loads on utilities.

- Reduces energy costs as maximum utility rates apply during utility peak use.

2.4 Develop a building heating and cooling schedule to allow for most economical use of energy.

- To avoid conditioning of air in empty buildings during night, weekends and holidays.

2.5 Inspect and adjust on a frequent basis all lights, equipment and controls to assure optimum performance.

- Reduce energy costs.
- Avoid equipment breakdown.

2.6 Organize source recovery programs for paper and cardboard.

- Source of revenue when sold to recycling industry.
- Recycled material is energy conserving.

2.7 Organize and support employee car, van pools, encourage compact cars.

- Save gasoline.
- Reduce traffic congestion.
- Reduce parking requirements.

2.8 Train staff to turn off business equipment when not in use.

2.9 Inspect building envelope to assure that weather seals and insulation are intact. Thermographic surveys can be very revealing.

- To maintain building envelope at original performance standard.

2.10 Window management of venetian blind & curtains to control solar gain.

- Reduce solar gain in summer to reduce cooling.
- Allow sun into building in winter to reduce lighting and heating.

2.11 Retrofit building to take advantage of new energy saving systems.

## 3. Tenure and the potential for energy conservation.

Each tenure category's ability to respond to energy conservation strategies is affected directly by the options available and the rewards for action taken. The two broad categories of tenure are ownership and leasing of either the whole or part of a building, each arrangement having its own characteristics affecting how energy can be saved. The main categories of tenure are as follows:

1. Owner and occupier of building
2. Owner landlord
3. Owner co-operative
4. Owner Condominium
5. Major tenant (whole building with self-contained energy systems)
6. Tenant in multiple occupancy building.

### 3.1 Owner and Occupier of Building

Full range of options 2.1 to 2.11 are available and action is rewarded with full recovery of savings from reduced utility bills. Implementation of conservation programs achieved through operating instructions, control adjustments, job description, staff education, conditions of employment. Government, institutional and corporate offices would be the main building types in this category.

### 3.2 Owner Landlord

The terms and conditions of the leases in effect have a great bearing on the range of options available to the landlord. The areas of action are improvements in the efficiency of building systems to deliver the environmental conditions committed to in the lease, and operations in the common areas. Reduced

operating costs would improve profitability, however as cost escalator clauses are common to most leases there is little incentive to keep energy consumption down. Until recently extensive capital outlays for retrofit systems for improved energy performance could not be passed on to the tenants though they would be benefiting through reduced escalation in the rates. Current practice on the part of major landlords is to have leasing clauses that allow the owner to recover, in the rent, the capital costs for energy conserving equipment.
(See Appendix XIII for sample clauses)
Office buildings, apartment buildings and shopping centres would be typical of buildings under the control of landlords.

3.3 Owner Co-operative or Condominium

Of the full range of options nearly all may be applied to a certain degree. Co-operation is rewarded in proportion to the share in the building and its expenses. Conservation programs that are mutually agreed upon by the owners are implemented through operating instructions, control adjustments, job descriptions, staff and owner education, conditions of employment, conditions of joint ownership. Co-operative and Condominium apartment buildings would be typical of this category.

3.4 Major Tenant

The major tenant occupying an entire building could act on a number of options affecting the use of the building such as times of operation, parking management, recycling, light and window control. The incentive to reduce energy consumption is, in the main, one of satisfaction gained from being energy righteous. Few lease arrangements reward the tenant for good energy management. However, some major lessors of buildings are now engaging professional energy management experts to assess and advise on leases and on the energy consumption characteristics of buildings they rent. The criteria for judgment are comprehensive and will no doubt give landlords incentive to construct and maintain energy

efficient buildings to meet the new market trend.

In the case where the tenant leases only the landlord's shell and is responsible for the installation and operation of his own energy systems then the options available for energy related programs are nearly as extensive as those for the owner occupant. Office buildings and anchor stores in a shopping centres would be representative of this category.

### 3.5 Tenant in a multiple occupancy building

Tenants in a multiple occupancy building are limited to energy conserving actions affecting their own suites with little reward for their effort other than the satisfaction of helping the common cause. Their chief power to improve their lot is in the choice of building they make in the first instance.

## 4. Conclusions:

Based on tenure the greatest opportunities to save energy would appear to be in buildings which the occupants own or share ownership, as the rewards for good performance accrue to those that brought them about. The form of tenure that offers the least motivation to conserve is the rental of a single unit of occupancy in a multiple occupancy building. Metering the use of each utility for each occupant would appear to be a solution to the dilemma of rewarding the true conserver. However, the costs for all the hardware, meter reading, and bookkeeping and billing could far outweight the benefits.

## 5. Recommendations:

5.1 Publicize examples of buildings with successful energy conserving programs.

5.2 Publicize an extensive list of options that can be adopted by owners and occupants.

5.3 Keep the public awareness for the need for continual energy conservation efforts, through education and advertising programs.

# XIV. COMPARISON ASSESSMENT OF THE VARIOUS SYSTEMS

## 1. Introduction

The assessment of the alternative system options is undertaken with due reference to the set of criteria set down in the terms of reference. The criteria include both quantitative and qualitative characteristics. The quantitative aspects have been investigated in depth for both individual building systems and district systems as to equipment, fuel and maintenance costs. The cost benefit analysis clearly favours district systems for both heating and cooling. A somewhat limited cost benefit analysis was undertaken for the heat pump, thermal storage, solar panel, and municipal waste options. In the case of heat pumps and thermal storages the energy savings are substantial while cost benefits are not always positive and depend considerably on the specifics of a building. When used in conjunction with a district system the thermal storage and heat pump systems would offer the greatest fuel efficiency and attendant cost savings.

The qualitative aspects don't lend themselves to clear and precise measurements and by nature are more subjective. The qualitative analysis therefore relies on judgment based on extensive experience in the field of energy planning.

## 2. Discussion

### 2.1 Individual Building Heating and Cooling

Plants:

ADVANTAGES: Standard, familiar, considerable experience with the technology.

Independent, individual in charge of own energy destiny.

DISADVANTAGES: Most costly in terms of equipment, energy and manpower costs

- least efficient due to lower fuel burning efficiencies for smaller boiler installations.
- least flexible as far as use of alternate fuel in future is concerned.

- each building will be graced with its own complement of smoke stacks and cooling towers.
- if oil heated the frequent fuel delivery via tanker trucks will add to congestion and pollution and tie up trucking bays to refill numerous individual storage tanks around the City Centre.
- The boiler efficiencies and stack emissions for the individual building systems are difficult to monitor on a consistent basis.
- costlier to install and maintain pollution control equipment.
- Multiplicity of boiler rooms increases the danger of fire or explosion.
- costly to convert to alternate fuel uses.
- noisy heating and cooling equipment in every building.
- larger overall operating staff requirements.

## 2.2 District Heating and Cooling Plant

ADVANTAGES:

- favourable fuel efficiency.
- least fuel cost due to favourable discount rates for bulk users.
- use of alternate energy sources such as industrial waste heat e.g. refineries, municipal waste, seasonal storage in aquifers and other natural storage media of "free" heat (solar waste etc.)
- Ease of conversion of the central system for alternate fuel use.
- Easiest system to monitor and maintain as its scale warrants highly trained full time staff therefore higher degree of reliability and safety.
- Pollution control equipment more economical to install and maintain.
- One central stack - rather then numerous stacks around the City Centre. (could become a symbol of progress and energy consciousness)

ADVANTAGES:

- reduced pollution (Scandinavia-recorded experience)
- fuel delivery to one point only.
- noise isolated to one building where sound reduction measures need be taken.

DISADVANTAGES:

- least familiar system.
- disruption of traffic due to underground distribution system which requires occasional repair.
- although most economical overall, requires major cash outlay in any one phase.
- requires commitment to build a major segment of the development to gain full economies.
- Few Canadian suppliers (heat meters in particular).

## XV. RECOMMENDATIONS

1. The design standards of National Research Council of Canada Document No. 16574 "Measures for Energy Conservation In New Buildings 1978" be adopted in the construction of Mississauga City Centre. The necessary inducement and / or regulations for this purpose should be put in place immediately.

2. It is recommended that installation of a district heating system for the City Centre be undertaken. The first and immediate step would require the preparation of a detailed design study for a low temperature hot water district heating system to establish the following:

    a) location of plant.
    b) ideal staging of development.
    c) land area requirements for plant.
    d) distribution network especially for pipe runs running in road allowances.
    e) sources of equipment.
    f) institutional and regulatory constraints.
    g) accurate cost budgets.

3. It is recommended that installation of a district cooling system for the City Centre be undertaken. The first step would require the preparation of a detailed design study for a district cooling system to establish the following:

    a) location of plant.
    b) ideal staging of development.
    c) land area requirements for plant.
    d) distribution network especially for pipe runs running in road allowances.
    e) sources of equipment.
    f) institutional and regulatory constraints.
    g) accurate cost budgets.

4. Variations in building form, envelope and systems do affect energy consumption and should be considered in the City Centre planning and building program. Such energy conserving alternate solutions should be brought out and seriously considered at the time a new structure is considered for a given site.

5. "Free" energy from the sun is at this time prejudiced by the high cost of the collector panels. Although the street grid orientation is not ideal for solar orientation the extensive areas of flat roof would be available for solar retrofits and therefore should be kept in mind as future option.

6. Encourage source separation recycling programs to recover valuable paper and cardboard. Encourage and support a Region of Peel project for a heat and material recovery plant that would process a large quantity of the regions waste. If located near the City Centre it could feed heat into a district system.

7. Encourage energy savings through the following transportation strategies.

   a) Encourage and enforce guidelines for pedestrian network as outlined in City Centre Secondary Plan.

   b) Formulate general strategies bearing on the amount and distribution of parking.

   c) Prepare a guideline for parking efficiencies and parking layouts with respect to energy efficiencies and require all to adhere to policy.

   d) Study the feasibility of establishing trucking and delivery consolidation terminals.

   e) Continue to encourage public transit operations.

   f) Undertake traffic management studies for Mississauga City Centre and the immediate surroundings to ensure ease of access, flow minimization of congestion.

g) Prepare education programs to promote energy conservation transportation practices.

h) Encourage mixed use development that includes user-oriented service retail within each development parcel in order that internal traffic movement be minimized.

NOTE: For detailed recommendations see Chapter entitled Transportation - Potential Conservation.

8. Microclimatic improvements can be made in the pedestrian walkway and open space areas particularly in the realm of wind control. Building form and placement along with landscaping features are viable tools for wind manipulation. The necessary inducements and / or regulations for this purpose should be put in place immediately.

NOTE: See Chapter on Microclimatic Considerations for detailed recommendations.

9. Programs for energy conservation in existing buildings are effective in reducing energy costs and consumption as witnessed by the experience of the program operating at Mississauga City Hall and Square One. Similar programs for all other existing buildings should be encouraged through publicity, direct reminders and other similar programs.

10. Tax inducements at the, Federal, Provincial, and Municipal levels to encourage investment in energy conservation equipment should be considered.

11. Institutional barriers that presently encumber the use of district systems and other energy conserving methods should be removed.

## General Notes and Explanation for Building Inventory Table

| | | |
|---|---|---|
| G.L.A. | - | Gross Leasable area. |
| G.B.A. | - | Gross Building Area - Excludes basements, mechanical and elevator penthouses. |
| $m^2$ | - | Square metres. To convert to square feet multiply by 10.76391. |
| ha | - | Hectare = 10,000 sq.metres. To convert to acres multiply by 2.471. |

Parking - Calculated on ultimate parking space standards, Page S1 Appendix A. Mississauga City Centre Plan.

Gross area per car = 32 $m^2$

For Hotels provide 1.25 car space/hotel room ultimately.

Except for Parcel 12 no parking has been calculated for community facilities as building areas for same are minor and ancillary to predominant building use.

Column 6 - Retail - Mall + service areas.
These areas have been calculated as follows:

Regional Shopping centre G.L.A. - 75% of the G.B.A. (Parcels 15 + 16 only) Public + Service 25% of the G.B.A.

| | | |
|---|---|---|
| When 35% or more of land use is retail: | G.L.A. = | 80% of the G.B.A. |
| | Public + Service = | 20% " " " |
| When retail use is less than 35% of land use: | G.L.A. = | 85% " " " |
| | Public + Service = | 15% " " " |

The above efficiencies are based on the assumption that larger retail complexes require more public and service space than those of lesser size.

Column 9 - Elevator, washrooms, circulation and service space in office buildings is calculated at 15% of gross building area.

Column 13 - The Residential Gross Building Area have been calculated as follows.

For units close to centre (Parcels 25, 26, 27, 28).

Assume 74 $m^2$ for apt. + 1 $m^2$ for recreation area = 75 $m^2$.

For units on periphery

Assume 93 $m^2$ + 1 $m^2$ for recreation area = 94 $m^2$

It is assumed that a larger number of small apartments i.e. Bachelors + 1 Bedrooms will be in Parcels 25, 26, 27, 28.

Column 14 - Only definition is for Parcel 12 which will contain the central library (18,587 $m^2$) theatre and concert hall (4646 $m^2$) community centre (2788 $m^2$) and health clinic (2323 $m^2$)

Remainder will be churches, indoor sports facilities etc.

Columns 15, 16, 17, 18, 19, 20 - Room + ancillary facilities = 75 $m^2$

Breakdown of Hotel G.B.A. as follows:

| | | |
|---|---|---|
| Bedroom ------------ | 70% | G.B.A. |
| Ancillary Fac. ------- | 20% | " |
| Lobbies + Circulation -- | 5% | " |
| Service Room Kitchens -- | 5% | " |

Columns 23 + 24 - Maximum site coverage given as a percentage of area including buildings and parking areas.

Column 25 - Building coverage computed by dividing Gross Building Area for parcel by average number of storeys.
This figure gives approximate size of building basements.

Column 27 - Covered parking spaces calculated to be 75% of total spaces required.

## DESIGN CRITERIA FOR BUILDING SERVICES AND BUILDING ENVELOPE

Skin of Buildings with Low Internal Energy Use

Housing units, apartments, motels, community facilities and heated commercial storage.

1. Thermal Resistance (R Value)

   Note: Thermal Resistance (R Value) noted below have been interpolated from the NRCC standards to suit Mississauga City Centre conditions of 4082 Heating Degree Days ($^{o}$C).

| | $M^2 . {}^{o}C/W$ |
|---|---|
| Walls | 2.7 |
| Below grade walls (min. 600 mm below adjacent grade) | 1.6 |
| Roof or ceiling assemblies | |
| Combustible construction | 5.0 |
| Non-combustible construction | 2.7 |
| Floor assemblies | |
| Combustible construction | 4.7 |
| Non-combustible construction | 2.7 |
| Perimeter slab on grade | |
| Slabs where heating ducts, pipes or resistance wiring are embedded in or beneath the slabs | 1.5 |
| Other than above | 1.0 |

2. Glazing

| | |
|---|---|
| Thermal resistance: | .3 $m^2 . {}^{o}C/W$ |
| Max. area: | 15% of floor area or 40% of wall area |

3. Doors

| | |
|---|---|
| Thermal resistance: | .7 $m^2 . {}^{o}C/W$ (where storm door is not provided) |

4. Infiltration (at 75 Pa pressure difference)

Windows: .775 $dm^3$/sec per metre of sash crack

Sliding glass door: 2.5 $dm^3$/sec per $m^2$ of door area

Swing doors: 6.35 $dm^3$/sec per $m^2$ of door area. (where storm doors or weather stripping are not provided)

Doors other than above: 17.0 $dm^3$/sec per m of crack.

Skin of Building with High Internal Energy Use
Office Buildings and Retail

1. Thermal Resistance (R Value)

| | $m^2.^oC/W$ |
|---|---|
| Walls | 2.1 |
| Below grade walls (min. 600 mm below adjacent grade) | 1.6 |
| Roof or ceiling assemblies | |
| Combustible construction | 4.0 |
| Non-combustible construction | 2.1 |
| Floor assemblies | |
| Combustible construction | 4.0 |
| Non-combustible construction | 2.1 |
| Perimeter slab on grade | |
| Slabs where heating ducts, pipes or resistance wiring are embedded in or beneath the slabs | 1.0 |
| Other than above | .8 |

2 Glazing

Same as item 3.2 except where exterior doors are protected by unheated vestibules or such doors are of the revolving type, single glazing may be used.

3 Doors

As item 3.3.

4 Infiltration

As item 3.4.

4.1 A door that separates heated space from the exterior to be protected with an enclosed vestibule excluding the following cases:

a) The door is a revolving door
b) The door is used primarily to facilitate vehicular movement or material handling
c) The door is not intended to be used as a general entrance door
d) The door opens directly from an enclosed space of less than $150m^2$ in area.

Heating, Cooling and Ventilating

1 Ventilation

1.1 Non-mechanical or natural ventilation of buildings shall conform to the requirements of the OBC, 1975.

1.2 Where mechanical ventilation is provided, the design air quantities used for such ventilation shall be the minimum values permitted in ASHRAE Standard 62-73, "Standards for Natural and Mechanical Ventilation", except when otherwise required by the OBC, 1975.

Lighting

.1 Range or recommended lighting levels in Dekalux

| | |
|---|---|
| Corridors, service areas or public spaces | 10 - 20 |
| Large circulation areas (malls, cafeterias, auditoriums) | 20 - 30 |
| Normal reading areas (gen. offices, private offices, classrooms) | 50 - 60 |
| Prolonged reading areas (accounting offices, libraries) | 60 - 80 |
| Critical visual task areas (drafting rooms) | 80 - 100 |
| Supermarkets | 75 - 100 |
| Retail stores | 50 - 75 |
| Parking indoors | 5 - 10 |
| Parking outdoors | 1 - 2 |

2 Notes re Recommended Lighting Levels

2.1 Ranges given allow for difficulty in seeing task performed.

2.2 It is assumed that supplementary lighting will be used where task illumination listed is insufficient.

2.3 Illumination levels listed are equal to or exceed minimum levels required by National Building Code of Canada 1977 and Ontario Building Code.

2.4 Lighting levels listed for supermarket and retail stores are ambient. F eature displays and showcase lighting levels are not included. Recommended contrast for large areas is 1 to 3, for small display areas 1 to 5.

2.5 Lighting levels for (office) normal reading areas, prolonged reading areas and critical visual task areas are assumed to be equivalent sphere illumination E.S.I. (or with little or no direct glare).

3 Connected Load for Lighting

3.1 Lighting sources and luminaire types shall be such that total connected lighting loads for office buildings, business and personal services major occupancy will not exceed 22 $W/m^2$ and for mercantile major occupancy will not exceed 60 $W/m^2$ of floor area.

.4 Multi Level Lighting and Switching

4.1 Each area should have provisions for multi level light switching to provide for different tasks such as cleaning, security, emergency, lunch periods, stocking and occupied/non-occupied periods.

Areas containing daylight should have provisions for manual or automatic switching of lights when daylight contribution provides required lighting levels.

## Basic Data For Energy Consumption Calculation

1. Housing

a) Unit size - app. 75 - 100 $m^2$/unit

b) Electricity demand - 13.75 $W/m^2$
Electricity consumption - .198 $GJ/m^2$/year (55 kW-hr/$m^2$/year) equivalent to 4000 hrs. of max. demand

c) Domestic hot water demand- 12.5 $W/m^2$

Domestic hot water consumption - .144 $GJ/m^2$/year (40 k W-hr/$m^2$/year) equivalent to 3200 hrs. of max. demand

d) Space heating demand - 46.6 $W/m^2$

Space heating consumption -.198 $GJ/m^2$/year (55 kW-hr/$m^2$/year) equivalent to 1181 hrs. of max. demand

The average monthly space heating demand is .4525 of the annual max. demand (as used for electrical bill calculations).

e) Above factors are based on Toronto Hydro and Ontario Hydro data for electrically heated apartments and also on O.L.C.K. computer simulations of residential heating requirements.

2. Offices

a) Electricity demand - 45 $W/m^2$
Electricity consumption - .396 $GJ/m^2$/year(110 kWH/$m^2$/year) equivalent to 2442 hrs. of demand
The average monthly demand is .834 of the annual max. demand (as used for electrical bill calculations)

b) Domestic hot water demand - 5 $W/m^2$
Domestic water consumption- .016 $GJ/m^2$/year(4.44 k WH/$m^2$/year)

c) Space heating demand - 37 $W/m^2$
Space heating consumption - .183 $GJ/m^2$/year
(50.9 k WH/$m^2$/year)
equivalent to 1376 hrs. of demand

d) Above factors are based on O.L.C.K. comptuter simulation of an energy conserving office building, utilizing Malton weather tape.

3. Retail

a) Electricity demand - 57.9 $W/m^2$
Electricity consumption - 1.08 $GJ/m^2$/year
(300 k WH/$m^2$/year)
equivalent to 5180 hrs. of demand

b) Domestic hot water demand- 23 W/m2
Domestic hot water consumption-.0749 $GJ/m^2$/year
(20.8 kWH/$m^2$/year)
equivalent to 904 hrs. of demand

c) Space heating demand - 39.2 $W/m^2$
Space heating consumption- .177 $GJ/m^2$/year
(49.2 k WH/$m^2$/year)
equivalent to 1255 hrs. of max. demand

d) Above factors are based on Square One data and Fairview Mall data. Regarding the domestic hot water consumption it is assumed that restaurants would be located in the retail component and 58,500 meals/day would be served (full meals), i.e. equivalent to one full meal per office worker in the office component of the complex. A.S.H.R.A.E. data indicates 2.4 US gal. for a full meal and 0.7 US gal. for a snack (grill, drive-in, luncheonette,sandwich shop).

4. Community

a) Electricity demand - 47.1 W/m$^2$

Electricity consumption - .45 GJ/m$^2$/year

(125.1 kWH/m$^2$/year)

equivalent to 2656 hrs. of demand

b) Domestic hot water demand - 5.3 W/m2

Domestic hot water consumption - .0175 GJ/m$^2$/year

(4.85 kWH/m$^2$/year)

equivalent to 915 hrs. of dema

c) Space heating demand - 38.7 W/m2

Space heating consumption- .204 GJ/m$^2$/year

(56.7 kWH/m2/year)

equivalent to 1465 hrs.of demand

5. Hotel

a) Electricity demand - 42.1 W/m$^2$

Electricity consumption - .628 GJ/m$^2$/year

(174.5 kWH/m$^2$/year)

equivalent to 4147 hrs.of demand

b) Domestic hot water demand - 15.7 W/m$^2$

Domestic hot water consumption -.123 GJ/m$^2$/year

(34.2 kWH/m$^2$/year)

equivalent to 2181 hrs.of dema

c) Space heating demand - 65.6 W/m$^2$

Space heating consumption- .595 GJ/m$^2$/year

(165.21 kWH/m$^2$/year)

equivalent to 2518 hrs.of demand

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 1 | | | | | | |
| Area 2.0 ha | | | | | | |
| Housing 200u | 20,000 | 250kW | 932kW | | 275kW | 10,800 GJ |
| | | 2,880GJ | 3,960GJ | 6,840GJ | 3,960GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 756GJ | 756 GJ |
| Street Lgts | | | | | 51GJ | 51 GJ |
| TOTAL | 20,000 | 2,880GJ | 3,960GJ | 6,840GJ | 3,960GJ | 11,608 GJ |
| | | | | | | 0.58GJ/m2 |
| (Parking 200 spaces) | | | | | | 5,804GJ/ha |
| Parcel No. 2 | | | | | | |
| Area 2.8 ha | | | | | | |
| Retail | 2,823 | 65kW | 111kW | | 163kW | 3,760 GJ |
| | | 211GJ | 500GJ | 711GJ | 3,049GJ | 1.33GJ/m2 |
| Housing 300u | 30,000 | 375kW | 1,398kW | | 413kW | 16,200 GJ |
| | | 4,320GJ | 5,940GJ | 10,260GJ | 5,940GJ | 0.54GJ/m2 |
| Comm. Fac. | 2,300 | 12kW | 89kW | | 108kW | 1,544 GJ |
| | | 40GJ | 469GJ | 509GJ | 1,035GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 1,589GJ | 1,589 GJ |
| Street Lgts | | | | | 51GJ | 51 GJ |
| TOTAL | 35,123 | 4,572GJ | 6,909GJ | 11,481GJ | 10,024GJ | 23,145 GJ |
| | | | | | | 0.66GJ/m2 |
| (Parking 421 spaces) | | | | | | 8,266GJ/ha |
| arcel No. 3 | | | | | | |
| rea 4.8 ha | | | | | | |
| etail | 2,823 | 65kW | 111kW | | 163kW | 3,760 GJ |
| | | 211GJ | 500GJ | 711GJ | 3,049GJ | 1.33GJ/m2 |
| ousing 400u | 40,000 | 500kW | 1,864kW | | 550kW | 21,600 GJ |
| | | 5,760GJ | 7,920GJ | 13,680GJ | 7,920GJ | 0.54GJ/m2 |
| omm. Fac. | 4,600 | 24kW | 178kW | | 217kW | 3,089 GJ |
| | | 81GJ | 938GJ | 1,019GJ | 2,070GJ | 0.67GJ/m2 |
| ov'd Prkng | | | | | 1,967GJ | 1,967 GJ |
| treet Lgts | | | | | 48GJ | 48 GJ |
| OTAL | 47,423 | 6,052GJ | 9,358GJ | 15,410GJ | 13,039GJ | 30,465 GJ |
| | | | | | | 0.64GJ/m2 |
| Parking 521 spaces) | | | | | | 6,347GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 4 | | | | | | |
| Area 4.4 ha | | | | | | |
| Retail | 5,647 | 130kW | 221kW | | 327kW | 7,521 GJ |
| | | 423GJ | 1,000GJ | 1,422GJ | 6,099GJ | 1.33GJ/m2 |
| Offices | 9,300 | 47kW | 344kW | | 419kW | 5,534 GJ |
| | | 149GJ | 1,702GJ | 1,851GJ | 3,683GJ | 0.60GJ/m2 |
| Housing 200u | 16,000 | 200kW | 746kW | | 220kW | 8,640 GJ |
| | | 2,304GJ | 3,168GJ | 5,472GJ | 3,168GJ | 0.54GJ/m2 |
| Comm. Fac. | 4,600 | 24kW | 178kW | | 217kW | 3,089 GJ |
| | | 81GJ | 938GJ | 1,019GJ | 2,070GJ | 0.67GJ/m2 |
| Hotel 400u | 30,000 | 471kW | 1,968kW | | 1,263kW | 40,380 GJ |
| | | 3,690GJ | 17,850GJ | 21,540GJ | 18,840GJ | 1.35GJ/m2 |
| Cov'd Prkng | | | | | 3,814GJ | 3,814 GJ |
| Street Lgts | | | | | 56GJ | 56 GJ |
| TOTAL | 65,547 | 6,646GJ | 24,658GJ | 31,304GJ | 33,860GJ | 69,035 GJ |
| | | | | | | 1.05GJ/m2 |
| (Parking 1,008 spaces) | | | | | | 15,690GJ/ha |
| Parcel No. 5 | | | | | | |
| Area 1.3 ha | | | | | | |
| Offices | 46,500 | 233kW | 1,721kW | | 2,093kW | 27,668 GJ |
| | | 744GJ | 8,510GJ | 9,254GJ | 18,414GJ | 0.60GJ/m2 |
| Cov'd Prkng | | | | | 1,932GJ | 1,932 GJ |
| Street Lgts | | | | | 37GJ | 37 GJ |
| TOTAL | 46,500 | 744GJ | 8,510GJ | 9,254GJ | 18,414GJ | 29,637 GJ |
| | | | | | | 0.64GJ/m2 |
| (Parking 511 spaces) | | | | | | 22,798GJ/ha |
| Parcel No. 6 | | | | | | |
| Area 3.8 ha | | | | | | |
| Retail | 10,823 | 249kW | 424kW | | 627kW | 14,415 GJ |
| | | 811GJ | 1,916GJ | 2,726GJ | 11,689GJ | 1.33GJ/m2 |
| Offices | 46,500 | 233kW | 1,721kW | | 2,093kW | 27,668 GJ |
| | | 744GJ | 8,510GJ | 9,254GJ | 18,414GJ | 0.60GJ/m2 |
| Housing 200u | 16,000 | 200kW | 746kW | | 220kW | 8,640 GJ |
| | | 2,304GJ | 3,168GJ | 5,472GJ | 3,168GJ | 0.54GJ/m2 |
| Comm. Fac. | 1,850 | 10kW | 72kW | | 87kW | 1,242 GJ |
| | | 32GJ | 377GJ | 410GJ | 833GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 4,182GJ | 4,182 GJ |
| Street Lgts | | | | | 62GJ | 62 GJ |
| TOTAL | 75,173 | 3,891GJ | 13,971GJ | 17,862GJ | 34,103GJ | 56,211 GJ |
| | | | | | | 0.75GJ/m2 |
| (Parking 1,106 spaces) | | | | | | 14,792GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| arcel No. 7 | | | | | | |
| rea 4.0 ha | | | | | | |
| etail | 33,875 | 779kW | 1,328kW | | 1,961kW | 45,118 GJ |
| | | 2,537GJ | 5,996GJ | 8,533GJ | 36,585GJ | 1.33GJ/m2 |
| ffices | 9,300 | 47kW | 344kW | | 419kW | 5,534 GJ |
| | | 149GJ | 1,702GJ | 1,851GJ | 3,683GJ | 0.60GJ/m2 |
| ousing 200u | 16,000 | 200kW | 746kW | | 220kW | 8,640 GJ |
| | | 2,304GJ | 3,168GJ | 5,472GJ | 3,168GJ | 0.54GJ/m2 |
| omm. Fac. | 1,350 | 7kW | 52kW | | 64kW | 907 GJ |
| | | 24GJ | 275GJ | 299GJ | 608GJ | 0.67GJ/m2 |
| ov'd Prkng | | | | | 5,550GJ | 5,550 GJ |
| treet Lgts | | | | | 39GJ | 39 GJ |
| OTAL | 60,525 | 5,014GJ | 11,141GJ | 16,155GJ | 44,043GJ | 65,788 GJ |
| | | | | | | 1.09GJ/m2 |
| Parking 1,467 spaces) | | | | | | 16,447GJ/ha |
| arcel No. 8 | | | | | | |
| rea 4.2 ha | | | | | | |
| etail | 28,125 | 647kW | 1,103kW | | 1,628kW | 37,460 GJ |
| | | 2,107GJ | 4,978GJ | 7,085GJ | 30,375GJ | 1.33GJ/m2 |
| ffices | 23,200 | 116kW | 858kW | | 1,044kW | 13,804 GJ |
| | | 371GJ | 4,246GJ | 4,617GJ | 9,187GJ | 0.60GJ/m2 |
| ousing 150u | 12,000 | 150kW | 559kW | | 165kW | 6,480 GJ |
| | | 1,728GJ | 2,376GJ | 4,104GJ | 2,376GJ | 0.54GJ/m2 |
| omm. Fac. | 1,350 | 7kW | 52kW | | 64kW | 907 GJ |
| | | 24GJ | 275GJ | 299GJ | 608GJ | 0.67GJ/m2 |
| ov'd Prkng | | | | | 5,192GJ | 5,192 GJ |
| treet Lgts | | | | | 68GJ | 68 GJ |
| OTAL | 64,675 | 4,229GJ | 11,875GJ | 16,105GJ | 42,546GJ | 63,911 GJ |
| | | | | | | 0.99GJ/m2 |
| arking 1,372 spaces) | | | | | | 15,217GJ/ha |
| arcel No. 9 | | | | | | |
| ea 3.0 ha | | | | | | |
| etail | 1,059 | 24kW | 42kW | | 61kW | 1,410 GJ |
| | | 79GJ | 187GJ | 267GJ | 1,144GJ | 1.33GJ/m2 |
| fices | 65,000 | 325kW | 2,405kW | | 2,925kW | 38,675 GJ |
| | | 1,040GJ | 11,895GJ | 12,935GJ | 25,740GJ | 0.60GJ/m2 |
| using 100u | 8,000 | 100kW | 373kW | | 110kW | 4,320 GJ |
| | | 1,152GJ | 1,584GJ | 2,736GJ | 1,584GJ | 0.54GJ/m2 |
| ov'd Prkng | | | | | 3,224GJ | 3,224 GJ |
| reet Lgts | | | | | 62GJ | 62 GJ |
| TAL | 74,059 | 2,271GJ | 13,666GJ | 15,938GJ | 28,468GJ | 47,692 GJ |
| | | | | | | 0.64GJ/m2 |
| arking 853 spaces) | | | | | | 15,897GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 10 | | | | | | |
| Area 5.2 ha | | | | | | |
| Retail | 10,823 | 249kW | 424kW | | 627kW | 14,415 GJ |
| | | 811GJ | 1,916GJ | 2,726GJ | 11,689GJ | 1.33GJ/m2 |
| Offices | 38,200 | 191kW | 1,413kW | | 1,719kW | 22,729 GJ |
| | | 611GJ | 6,991GJ | 7,602GJ | 15,127GJ | 0.60GJ/m2 |
| Housing 250u | 20,000 | 250kW | 932kW | | 275kW | 10,800 GJ |
| | | 2,880GJ | 3,960GJ | 6,840GJ | 3,960GJ | 0.54GJ/m2 |
| Comm. Fac. | 1,750 | 9kW | 68kW | | 82kW | 1,175 GJ |
| | | 31GJ | 357GJ | 388GJ | 788GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 4,026GJ | 4,026 GJ |
| Street Lgts | | | | | 77GJ | 77 GJ |
| TOTAL | 70,773 | 4,332GJ | 13,223GJ | 17,556GJ | 31,564GJ | 53,224 GJ |
| | | | | | | 0.75GJ/m2 |
| (Parking 1,065 spaces) | | | | | | 10,235GJ/ha |
| Parcel No. 11 | | | | | | |
| Area 3.8 ha | | | | | | |
| Retail | 40,000 | 920kW | 1,568kW | | 2,316kW | 53,276 GJ |
| | | 2,996GJ | 7,080GJ | 10,076GJ | 43,200GJ | 1.33GJ/m2 |
| Offices | 23,200 | 116kW | 858kW | | 1,044kW | 13,804 GJ |
| | | 371GJ | 4,246GJ | 4,617GJ | 9,187GJ | 0.60GJ/m2 |
| Comm. Fac. | 2,300 | 12kW | 89kW | | 108kW | 1,544 GJ |
| | | 40GJ | 469GJ | 509GJ | 1,035GJ | 0.67GJ/m2 |
| Hotel 600u | 45,000 | 707kW | 2,952kW | | 1,895kW | 60,570 GJ |
| | | 5,535GJ | 26,775GJ | 32,310GJ | 28,260GJ | 1.35GJ/m2 |
| Cov'd Prkng | | | | | 9,010GJ | 9,010 GJ |
| Street Lgts | | | | | 30GJ | 30 GJ |
| TOTAL | 110,500 | 8,942GJ | 38,570GJ | 47,512GJ | 81,682GJ | 138,236 GJ |
| | | | | | | 1.25GJ/m2 |
| (Parking 2,381 spaces) | | | | | | 36,378GJ/ha |
| Parcel No. 12 | | | | | | |
| Area 5.4 ha | | | | | | |
| Retail | 5,176 | 119kW | 203kW | | 300kW | 6,894 GJ |
| | | 388GJ | 916GJ | 1,304GJ | 5,590GJ | 1.33GJ/m2 |
| Offices | 51,000 | 255kW | 3,287kW | | 2,860kW | 62,844 GJ |
| | | 816GJ | 25,570GJ | 26,386GJ | 36,458GJ | 1.23GJ/m2 |
| Comm. Fac. | 27,900 | 148kW | 1,080kW | | 1,314kW | 18,735 GJ |
| | | 488GJ | 5,692GJ | 6,180GJ | 12,555GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 3,996GJ | 3,996 GJ |
| Street Lgts | | | | | 76GJ | 76 GJ |
| TOTAL | 84,076 | 1,692GJ | 32,178GJ | 33,870GJ | 54,603GJ | 92,546 GJ |
| | | | | | | 1.10GJ/m2 |
| (Parking 1,057 spaces) | | | | | | 17,138GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 13 | | | | | | |
| Area 2.6 ha | | | | | | |
| Retail | 1,059 | 24kW | 42kW | | 61kW | 1,410 GJ |
| | | 79GJ | 187GJ | 267GJ | 1,144GJ | 1.33GJ/m2 |
| Offices | 60,400 | 302kW | 2,235kW | | 2,718kW | 35,938 GJ |
| | | 966GJ | 11,053GJ | 12,020GJ | 23,918GJ | 0.60GJ/m2 |
| Housing 150u | 12,000 | 150kW | 559kW | | 165kW | 6,480 GJ |
| | | 1,728GJ | 2,376GJ | 4,104GJ | 2,376GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 3,224GJ | 3,224 GJ |
| Street Lgts | | | | | 47GJ | 47 GJ |
| TOTAL | 73,459 | 2,774GJ | 13,617GJ | 16,390GJ | 27,438GJ | 47,101 GJ |
| | | | | | | 0.64GJ/m2 |
| (Parking 852 spaces) | | | | | | 18,116GJ/ha |
| Parcel No. 14 | | | | | | |
| Area 2.0 ha | | | | | | |
| Retail | 2,823 | 65kW | 111kW | | 163kW | 3,760 GJ |
| | | 211GJ | 500GJ | 711GJ | 3,049GJ | 1.33GJ/m2 |
| Offices | 27,900 | 140kW | 1,032kW | | 1,256kW | 16,601 GJ |
| | | 446GJ | 5,106GJ | 5,552GJ | 11,048GJ | 0.60GJ/m2 |
| Housing 200u | 16,000 | 200kW | 746kW | | 220kW | 8,640 GJ |
| | | 2,304GJ | 3,168GJ | 5,472GJ | 3,168GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 2,305GJ | 2,305 GJ |
| Street Lgts | | | | | 39GJ | 39 GJ |
| TOTAL | 46,723 | 2,962GJ | 8,773GJ | 11,735GJ | 17,265GJ | 31,346 GJ |
| | | | | | | 0.67GJ/m2 |
| (Parking 610 spaces) | | | | | | 15,673GJ/ha |
| Parcel No. 15 | | | | | | |
| Area 13.0 ha | | | | | | |
| Retail | 92,666 | 2,131kW | 3,633kW | | 5,365kW | 123,422 GJ |
| | | 6,941GJ | 16,402GJ | 23,343GJ | 100,079GJ | 1.33GJ/m2 |
| Offices | 25,000 | 125kW | 925kW | | 1,125kW | 14,875 GJ |
| | | 400GJ | 4,575GJ | 4,975GJ | 9,900GJ | 0.60GJ/m2 |
| Housing 350u | 28,000 | 350kW | 1,305kW | | 385kW | 15,120 GJ |
| | | 4,032GJ | 5,544GJ | 9,576GJ | 5,544GJ | 0.54GJ/m2 |
| Comm. Fac. | 500 | 3kW | 19kW | | 24kW | 336 GJ |
| | | 9GJ | 102GJ | 111GJ | 225GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 13,668GJ | 13,668 GJ |
| Street Lgts | | | | | 62GJ | 62 GJ |
| TOTAL | 146,166 | 11,381GJ | 26,623GJ | 38,004GJ | 115,748GJ | 167,484 GJ |
| | | | | | | 1.15GJ/m2 |
| (Parking 3,613 spaces) | | | | | | 12,883GJ/ha |

## MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 16 | | | | | | |
| Area 18.0 ha | | | | | | |
| Retail | 192,266 | 4,422kW | 7,537kW | | 11,132kW | 256,079 GJ |
| | | 14,401GJ | 34,031GJ | 48,432GJ | 207,647GJ | 1.33GJ/m2 |
| Offices | 67,000 | 335kW | 2,479kW | | 3,015kW | 39,865 GJ |
| | | 1,072GJ | 12,261GJ | 13,333GJ | 26,532GJ | 0.60GJ/m2 |
| Housing 350u | 28,000 | 350kW | 1,305kW | | 385kW | 15,120 GJ |
| | | 4,032GJ | 5,544GJ | 9,576GJ | 5,544GJ | 0.54GJ/m2 |
| Comm. Fac. | 900 | 5kW | 35kW | | 42kW | 604 GJ |
| | | 16GJ | 184GJ | 199GJ | 405GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 27,580GJ | 27,580 GJ |
| Street Lgts | | | | | 71GJ | 71 GJ |
| TOTAL | 288,166 | 19,520GJ | 52,020GJ | 71,540GJ | 240,128GJ | 339,320 GJ |
| | | | | | | 1.18GJ/m2 |
| (Parking 7,288 spaces) | | | | | | 18,851GJ/ha |
| Parcel No. 17 | | | | | | |
| Area 2.8 ha | | | | | | |
| Retail | 3,176 | 73kW | 124kW | | 184kW | 4,230 GJ |
| | | 238GJ | 562GJ | 800GJ | 3,430GJ | 1.33GJ/m2 |
| Offices | 37,100 | 186kW | 1,839kW | | 1,858kW | 32,894 GJ |
| | | 594GJ | 12,195GJ | 12,789GJ | 20,105GJ | 0.89GJ/m2 |
| Housing 100u | 8,000 | 100kW | 373kW | | 110kW | 4,320 GJ |
| | | 1,152GJ | 1,584GJ | 2,736GJ | 1,584GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 2,361GJ | 2,361 GJ |
| Street Lgts | | | | | 44GJ | 44 GJ |
| TOTAL | 48,276 | 1,983GJ | 14,341GJ | 16,325GJ | 25,120GJ | 43,850 GJ |
| | | | | | | 0.91GJ/m2 |
| (Parking 624 spaces) | | | | | | 15,661GJ/ha |
| Parcel No. 18 | | | | | | |
| Area 2.1 ha | | | | | | |
| Retail | 1,059 | 24kW | 42kW | | 61kW | 1,410 GJ |
| | | 79GJ | 187GJ | 267GJ | 1,144GJ | 1.33GJ/m2 |
| Offices | 74,200 | 371kW | 2,745kW | | 3,339kW | 44,149 GJ |
| | | 1,187GJ | 13,579GJ | 14,766GJ | 29,383GJ | 0.60GJ/m2 |
| Cov'd Prkng | | | | | 3,229GJ | 3,229 GJ |
| Street Lgts | | | | | 33GJ | 33 GJ |
| TOTAL | 75,259 | 1,267GJ | 13,766GJ | 15,033GJ | 30,527GJ | 48,822 GJ |
| | | | | | | 0.65GJ/m2 |
| (Parking 854 spaces) | | | | | | 23,249GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 19 | | | | | | |
| Area 1.6 ha | | | | | | |
| Retail | 2,117 | 49kW | 83kW | | 123kW | 2,820 GJ |
| | | 159GJ | 375GJ | 533GJ | 2,286GJ | 1.33GJ/m2 |
| Offices | 18,600 | 93kW | 688kW | | 837kW | 11,067 GJ |
| | | 298GJ | 3,404GJ | 3,701GJ | 7,366GJ | 0.60GJ/m2 |
| Housing 150u | 12,000 | 150kW | 559kW | | 165kW | 6,480 GJ |
| | | 1,728GJ | 2,376GJ | 4,104GJ | 2,376GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 1,629GJ | 1,629 GJ |
| Street Lgts | | | | | 33GJ | 33 GJ |
| TOTAL | 32,717 | 2,184GJ | 6,155GJ | 8,339GJ | 12,028GJ | 22,030 GJ |
| | | | | | | 0.67GJ/m2 |
| (Parking 431 spaces) | | | | | | 13,769GJ/ha |
| Parcel No. 20 | | | | | | |
| Area 1.4 ha | | | | | | |
| Retail | 1,059 | 24kW | 42kW | | 61kW | 1,410 GJ |
| | | 79GJ | 187GJ | 267GJ | 1,144GJ | 1.33GJ/m2 |
| Offices | 34,000 | 170kW | 1,258kW | | 1,530kW | 20,230 GJ |
| | | 544GJ | 6,222GJ | 6,766GJ | 13,464GJ | 0.60GJ/m2 |
| Cov'd Prkng | | | | | 1,559GJ | 1,559 GJ |
| Street Lgts | | | | | 35GJ | 35 GJ |
| TOTAL | 35,059 | 623GJ | 6,409GJ | 7,033GJ | 14,608GJ | 23,235 GJ |
| | | | | | | 0.66GJ/m2 |
| (Parking 412 spaces) | | | | | | 16,596GJ/ha |
| Parcel No. 21 | | | | | | |
| Area 1.5 ha | | | | | | |
| Retail | 1,059 | 24kW | 42kW | | 61kW | 1,410 GJ |
| | | 79GJ | 187GJ | 267GJ | 1,144GJ | 1.33GJ/m2 |
| Offices | 7,900 | 40kW | 292kW | | 356kW | 4,701 GJ |
| | | 126GJ | 1,446GJ | 1,572GJ | 3,128GJ | 0.60GJ/m2 |
| Hotel 400u | 30,000 | 471kW | 1,968kW | | 1,263kW | 40,380 GJ |
| | | 3,690GJ | 17,850GJ | 21,540GJ | 18,840GJ | 1.35GJ/m2 |
| Cov'd Prkng | | | | | 2,361GJ | 2,361 GJ |
| Street Lgts | | | | | 38GJ | 38 GJ |
| TOTAL | 38,959 | 3,896GJ | 19,483GJ | 23,379GJ | 23,112GJ | 48,891 GJ |
| | | | | | | 1.25GJ/m2 |
| (Parking 624 spaces) | | | | | | 32,594GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 22 | | | | | | |
| Area 4.0 ha | | | | | | |
| Retail | 1,059 | 24kW | 42kW | | 61kW | 1,410 GJ |
| | | 79GJ | 187GJ | 267GJ | 1,144GJ | 1.33GJ/m2 |
| Offices | 88,000 | 440kW | 3,550kW | | 4,079kW | 59,195 GJ |
| | | 1,408GJ | 19,519GJ | 20,927GJ | 38,268GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 3,804GJ | 3,804 GJ |
| Street Lgts | | | | | 50GJ | 50 GJ |
| TOTAL | 89,059 | 1,487GJ | 19,706GJ | 21,193GJ | 39,412GJ | 64,460 GJ |
| | | | | | | 0.72GJ/m2 |
| (Parking 1,006 spaces) | | | | | | 16,115GJ/ha |
| Parcel No. 23 | | | | | | |
| Area 7.5 ha | | | | | | |
| Retail | 15,294 | 352kW | 600kW | | 886kW | 20,370 GJ |
| | | 1,146GJ | 2,707GJ | 3,853GJ | 16,518GJ | 1.33GJ/m2 |
| Offices | 93,000 | 465kW | 6,479kW | | 5,411kW | 125,858 GJ |
| | | 1,488GJ | 52,254GJ | 53,742GJ | 72,116GJ | 1.35GJ/m2 |
| Comm. Fac. | 4,600 | 24kW | 178kW | | 217kW | 3,089 GJ |
| | | 81GJ | 938GJ | 1,019GJ | 2,070GJ | 0.67GJ/m2 |
| Cov'd Prkng | | | | | 5,984GJ | 5,984 GJ |
| Street Lgts | | | | | 81GJ | 81 GJ |
| TOTAL | 112,894 | 2,714GJ | 55,899GJ | 58,613GJ | 90,703GJ | 155,382 GJ |
| | | | | | | 1.38GJ/m2 |
| (Parking 1,582 spaces) | | | | | | 20,718GJ/ha |
| Parcel No. 24 | | | | | | |
| Area 2.1 ha | | | | | | |
| Offices | 46,400 | 232kW | 1,717kW | | 2,088kW | 27,608 GJ |
| | | 742GJ | 8,491GJ | 9,234GJ | 18,374GJ | 0.60GJ/m2 |
| Cov'd Prkng | | | | | 1,927GJ | 1,927 GJ |
| Street Lgts | | | | | 40GJ | 40 GJ |
| TOTAL | 46,400 | 742GJ | 8,491GJ | 9,234GJ | 18,374GJ | 29,576 GJ |
| | | | | | | 0.64GJ/m2 |
| (Parking 510 spaces) | | | | | | 14,084GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 25 | | | | | | |
| Area 2.0 ha | | | | | | |
| Housing 500u | 40,000 | 500kW | 1,864kW | | 550kW | 21,600 GJ |
| | | 5,760GJ | 7,920GJ | 13,680GJ | 7,920GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 1,892GJ | 1,892 GJ |
| Street Lgts | | | | | 38GJ | 38 GJ |
| TOTAL | 40,000 | 5,760GJ | 7,920GJ | 13,680GJ | 7,920GJ | 23,531 GJ |
| | | | | | | 0.59GJ/m2 |
| (Parking 500 spaces) | | | | | | 11,766GJ/ha |
| Parcel No. 26 | | | | | | |
| Area 3.6 ha | | | | | | |
| Offices | 55,700 | 279kW | 2,061kW | | 2,507kW | 33,142 GJ |
| | | 891GJ | 10,193GJ | 11,084GJ | 22,057GJ | 0.60GJ/m2 |
| Housing 225u | 18,000 | 225kW | 839kW | | 248kW | 9,720 GJ |
| | | 2,592GJ | 3,564GJ | 6,156GJ | 3,564GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 3,163GJ | 3,163 GJ |
| Street Lgts | | | | | 48GJ | 48 GJ |
| TOTAL | 73,700 | 3,483GJ | 13,757GJ | 17,240GJ | 25,621GJ | 46,074 GJ |
| | | | | | | 0.63GJ/m2 |
| (Parking 837 spaces) | | | | | | 12,798GJ/ha |
| Parcel No. 27 | | | | | | |
| Area 3.1 ha | | | | | | |
| Housing 775u | 62,000 | 775kW | 2,889kW | | 853kW | 33,480 GJ |
| | | 8,928GJ | 12,276GJ | 21,204GJ | 12,276GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 2,931GJ | 2,931 GJ |
| Street Lgts | | | | | 43GJ | 43 GJ |
| TOTAL | 62,000 | 8,928GJ | 12,276GJ | 21,204GJ | 12,276GJ | 36,455 GJ |
| | | | | | | 0.59GJ/m2 |
| (Parking 775 spaces) | | | | | | 11,760GJ/ha |

## MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 28 | | | | | | |
| Area 8.2 ha | | | | | | |
| Offices | 67,300 | 337kW | 2,490kW | | 3,029kW | 40,044 GJ |
| | | 1,077GJ | 12,316GJ | 13,393GJ | 26,651GJ | 0.60GJ/m2 |
| Housing 240u | 19,200 | 240kW | 895kW | | 264kW | 10,368 GJ |
| | | 2,765GJ | 3,802GJ | 6,566GJ | 3,802GJ | 0.54GJ/m2 |
| Hotel 600u | 45,000 | 707kW | 2,952kW | | 1,895kW | 60,570 GJ |
| | | 5,535GJ | 26,775GJ | 32,310GJ | 28,260GJ | 1.35GJ/m2 |
| Cov'd Prkng | | | | | 6,546GJ | 6,546 GJ |
| Street Lgts | | | | | 72GJ | 72 GJ |
| TOTAL | 131,500 | 9,377GJ | 42,893GJ | 52,269GJ | 58,712GJ | 117,601 GJ |
| | | | | | | 0.89GJ/m2 |
| (Parking 1,730 spaces) | | | | | | 14,342GJ/ha |
| Parcel No. 29 | | | | | | |
| Area 3.3 ha | | | | | | |
| Offices | 18,600 | 93kW | 688kW | | 837kW | 11,067 GJ |
| | | 298GJ | 3,404GJ | 3,701GJ | 7,366GJ | 0.60GJ/m2 |
| Cov'd Prkng | | | | | 772GJ | 772 GJ |
| Street Lgts | | | | | 47GJ | 47 GJ |
| TOTAL | 18,600 | 298GJ | 3,404GJ | 3,701GJ | 7,366GJ | 11,886 GJ |
| | | | | | | 0.64GJ/m2 |
| (Parking 204 spaces) | | | | | | 3,602GJ/ha |
| Parcel No. 30 | | | | | | |
| Area 8.8 ha | | | | | | |
| Offices | 62,700 | 314kW | 2,320kW | | 2,822kW | 37,307 GJ |
| | | 1,003GJ | 11,474GJ | 12,477GJ | 24,829GJ | 0.60GJ/m2 |
| Cov'd Prkng | | | | | 2,603GJ | 2,603 GJ |
| Street Lgts | | | | | 74GJ | 74 GJ |
| TOTAL | 62,700 | 1,003GJ | 11,474GJ | 12,477GJ | 24,829GJ | 39,984 GJ |
| | | | | | | 0.64GJ/m2 |
| (Parking 689 spaces) | | | | | | 4,544GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 31 | | | | | | |
| Area 9.9 ha | | | | | | |
| Offices | 74,300 | 372kW | 4,400kW | | 4,010kW | 82,531 GJ |
| | | 1,189GJ | 32,743GJ | 33,932GJ | 48,598GJ | 1.11GJ/m2 |
| Cov'd Prkng | | | | | 3,088GJ | 3,088 GJ |
| Street Lgts | | | | | 93GJ | 93 GJ |
| TOTAL | 74,300 | 1,189GJ | 32,743GJ | 33,932GJ | 48,598GJ | 85,712 GJ |
| | | | | | | 1.15GJ/m2 |
| (Parking 817 spaces) | | | | | | 8,658GJ/ha |
| Parcel No. 32 | | | | | | |
| Area 2.1 ha | | | | | | |
| Housing 460u | 41,400 | 518kW | 1,929kW | | 569kW | 22,356 GJ |
| | | 5,962GJ | 8,197GJ | 14,159GJ | 8,197GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 1,740GJ | 1,740 GJ |
| Street Lgts | | | | | 36GJ | 36 GJ |
| TOTAL | 41,400 | 5,962GJ | 8,197GJ | 14,159GJ | 8,197GJ | 24,134 GJ |
| | | | | | | 0.58GJ/m2 |
| (Parking 460 spaces) | | | | | | 11,492GJ/ha |
| Parcel No. 33 | | | | | | |
| Area 4.1 ha | | | | | | |
| Housing 920u | 82,800 | 1,035kW | 3,858kW | | 1,139kW | 44,712 GJ |
| | | 11,923GJ | 16,394GJ | 28,318GJ | 16,394GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 3,481GJ | 3,481 GJ |
| Street Lgts | | | | | 53GJ | 53 GJ |
| TOTAL | 82,800 | 11,923GJ | 16,394GJ | 28,318GJ | 16,394GJ | 48,247 GJ |
| | | | | | | 0.58GJ/m2 |
| (Parking 920 spaces) | | | | | | 11,768GJ/ha |

MISSISSAUGA CITY CENTRE - PROJECTED ANNUAL ENERGY CONSUMPTION

| Building Type | Bldg Area m2 Gros | Domestic Hot Water | Space Heating | Heating Energy | Electricl Energy | Total Energy |
|---|---|---|---|---|---|---|
| Parcel No. 34 | | | | | | |
| Area 3.8 ha | | | | | | . |
| Housing 680u | 54,400 | 680kW | 2,535kW | | 748kW | 29,376 GJ |
| | | 7,834GJ | 10,771GJ | 18,605GJ | 10,771GJ | 0.54GJ/m2 |
| Cov'd Prkng | | | | | 2,573GJ | 2,573 GJ |
| Street Lgts | | | | | 30GJ | 30 GJ |
| TOTAL | 54,400 | 7,834GJ | 10,771GJ | 18,605GJ | 10,771GJ | 31,980 GJ |
| | | | | | | 0.59GJ/m2 |
| (Parking 680 spaces) | | | | | | 8,416GJ/ha |

## District Heating vs. Individual Building Heating - Life Cycle Cost Analysis

1. Assumptions

a) City Centre will grow uniformly to its ultimate density in 25 years (1980 - 2005).

b) Ultimate heating energy consumption 750,000 GJ/Year (increasing in increments of 30,000 GJ each year for 25 years).

c) Annual load factor is 30%, resulting in the ultimate demand on the district heating system of 80 MW.

d) Capital cost data, fuel cost escalation and discount rates are in terms of real (1980) dollars (constant dollars).

e) Average escalation for gas and oil - 4.5% (over inflation)
Average escalation for electricity - 1.0% (over inflation)
Discount rate: Government - 2.0% (over inflation)
Private - 6.0% (over inflation)
(Fuel escalation rates are averages in real 1980 dollars, taken from estimates of the Ministry of Energy.)

f) Capital investment, heating plant staff expenses and maintenance expenses for individual plants will increase uniformly over the 25 years.

g) Capital investment for the district heating system (central plant and the distribution mains) will occur in five increments as follows:

| Year | Real (1980 dollars |
|---|---|
| 1980 | 1,920,000.00 |
| 1981 | 0 |
| 1982 | 0 |
| 1983 | 0 |
| 1984 | 0 |
| 1985 | 1,920,000.00 |
| 1986 | 0 |
| 1987 | 0 |
| 1988 | 0 |
| 1989 | 0 |
| 1990 | 1,920,000.00 |
| 1991 | 0 |
| 1992 | 0 |
| 1993 | 0 |
| 1994 | 0 |
| 1995 | 1,920,000.00 |
| 1996 | 0 |
| 1997 | 0 |
| 1998 | 0 |
| 1999 | 0 |
| 2000 | 1,920,000.00 |
| 2001 | 0 |
| 2002 | 0 |
| 2003 | 0 |
| 2004 | 0 |

It should be noted that the preceding pattern for capital requirements will give conservative (higher) Life Cycle Costs than the more likely pattern of slower initial growth and accelerated growth towards the end of the development period.

h) District Heating System maintenance expenses will increase uniformly over the 25 years from $9,600 in first year to $240,000 in the 25 year (real 1980 dollars), i.e. about 2.5% of the ultimate capital cost of the system.

i) District Heating System staff expenses will be as follows:

| Year | Real (1980) dollars/year |
|---|---|
| 1980 | 124,000.00 |
| 1 | 124,000.00 |
| 2 | 124,000.00 |
| 3 | 124,000.00 |
| 4 | 124,000.00 |
| 5 | 155,000.00 |
| 6 | 155,000.00 |
| 7 | 155,000.00 |
| 8 | 155,000.00 |
| 9 | 155,000.00 |
| 1990 | 186,000.00 |
| 1 | 186,000.00 |
| 2 | 186,000.00 |
| 3 | 186,000.00 |
| 4 | 186,000.00 |
| 5 | 217,000.00 |
| 6 | 217,000.00 |
| 7 | 217,000.00 |
| 8 | 217,000.00 |
| 9 | 217,000.00 |
| 2000 | 248,000.00 |
| 1 | 248,000.00 |
| 2 | 248,000.00 |
| 3 | 248,000.00 |
| 4 | 248,000.00 |

The above staff expense pattern is rather conservative, since it is assumed that 50% of the ultimate staff is required in the first year of system operation. The remaining 50% is added in five steps (every five years).

j) Heating Plant Staff expenses for individual building plants is assumed to increase every year in direct proportion to the size of the development. The annual increment for this expense is assumed at $25,700.00 (20% of the initial year fuel cost).

k) Maintenance expense for individual building plants is assumed at $7,500.00 in the initial year.

l) Fuel usage will increase uniformly over the 25 years for both types of systems.

m) Unit fuel costs for 1980 are as follows:

| | | |
|---|---|---|
| Gas, individual plant | - $3.00/GJ | (3.16$/MCF) |
| Gas, central plant | - $2.60/GJ | (2.75$/MCF) |
| Light oil (individual plant) | - $4.50/GJ | ( .78$/Gal) |
| Residual oil (central plant) | - $2.67/GJ | (.508$/Gal) |

n) Seasonal plant efficiency for individual plants - 70%
Seasonal plant efficiency for district heating plant - 75%
(after allowance for distribution piping losses).

o) Life Cycle Cost in terms of Present Discounted Value for 25 years is the appropriate method for economic evaluation.

p) Capital, operating and maintenance costs are derived from published reports on district heating in Ontario.

2. Life Cycle Costs (Present Discounted Value for 25 Years)

a) District Heating System

| | | Discount Rate | |
|---|---|---|---|
| | | 2% | 6% |
| 1. | Investment | $7,952,765.00 | $5,826,668.00 |
| 2. | Staff | $3,582,259.00 | $2,284,172.00 |
| 3. | Maintenance | | |
| | $9,600 x 238.458 | $2,289,196.00 | |
| | $9,600 x 136.482 | | $1,310,227.00 |
| 4. | Fuel - Natural Gas | | |
| | 30,000GJx2.60/.75x 483.721 | $50,306,984.00 | |
| | 30,000GJx2.60/.75 259.695 | | $27,008,280.00 |
| | Total: | $64,131,204.00 | $36,429,347.00 |

Note: Fuel Cost with residual oil is 2.7% higher than with natural gas, resulting in totals of $65,489,493 and $37,158,571 for discounting of 2% and 6% respectively.

b) Individual Heating Plants

| | | Discount Rate | |
|---|---|---|---|
| | | 2% | 6% |
| 1. | Investment | | |
| | $537,200 x 19.914 | $10,697,801.00 | |
| | $537,200 x 13.550 | | $7,279,060.00 |
| 2. | Staff | | |
| | $25,700 x 238.458 | $ 6,128,371.00 | |
| | $25,700 x 136.482 | | $3,507,587.00 |
| 3. | Maintenance | | |
| | $7,500 x 238.458 | $ 1,788,435.00 | |
| | $7,500 x 136.482 | | $1,023,615.00 |
| 4. | Fuel - Natural Gas | | |
| | 30,000GJx3.00/.7x 483.721 | $62,192,700.00 | |
| | 30,000GJx3.00/.7x 259.695 | | $33,389,354.00 |
| | Total: | $80,807,307.00 | $45,199,616.00 |

Note: Fuel cost with light oil is 46.7% higher than with natural gas, resulting in totals of $109,851,298.00 $60,792,444.00 for discounting of 2% and 6% respectively.

c) Individual Electrical Heating Plants

| | Discount Rate | |
|---|---|---|
| | 2% | 6% |
| 1. Investment | | |
| $143,300 x 19.914 | $2,674,450 | |
| $143,300 x 13.550 | | $1,819,765 |
| 2. Staff | | |
| $2,570 x 238.458 | 612,837 | |
| $2,500 x 136.482 | | 350,759 |
| 3. Maintenance | | |
| $750 x 238.458 | 178,844 | |
| $750 x 136.482 | | 102,362 |
| 4. Energy | | |
| 30,000GJx8.4x278.093 | 70,079,436 | |
| 30,000GJx8.4x156.779 | | 39,508,308 |
| Total: | $73,545,567 | $41,781,194 |

## 4. District Cooling vs. Individual Building Cooling Plant - Life Cycle Cost Analysis

### .1. Assumption

a) City Centre will grow uniformly to its ultimate density in 25 years (1980 - 2005).

b) Ultimate cooling energy consumption 115,000 GJ/Year (increasing in increments of 4,600 GJ each year for 25 years).

c) Annual load factor is 30%, resulting in the ultimate demand on the district cooling system of 16MW.

d) Capital cost data, fuel cost escalation and discount rates are in terms of real (1980) dollars (constant dollars).

e)

| | | |
|---|---|---|
| Average escalation for electricity | | - 1.0% (over inflation) |
| Discount rate | Government | - 2.0% (over inflation) |
| | Private | - 6.0% |

(Energy escalation rates are averages in real 1980 dollars, taken from estimates of the Ministry of Energy Statistics Dept.)

f) Capital investment, cooling plant staff expenses and maintenance expenses for individual plants will increase uniformly over the 25 years.

g) Capital investment for the district cooling system (central plant and the distribution mains) will occur in five increments as follows:

| Year | Real (1980) dollars |
|---|---|
| 1980 | 2,650,000.00 |
| 1981 | 0 |
| 1982 | 0 |
| 1983 | 0 |
| 1984 | 0 |
| 1985 | 2,650,000.00 |
| 1986 | 0 |
| 1987 | 0 |
| 1988 | 0 |
| 1989 | 0 |
| 1990 | 2,650,000.00 |
| 1991 | 0 |
| 1992 | 0 |
| 1993 | 0 |
| 1994 | 0 |
| 1995 | 2,650,000.00 |
| 1996 | 0 |
| 1997 | 0 |
| 1998 | 0 |
| 1999 | 0 |
| 2000 | 2,650,000.00 |
| 2001 | 0 |
| 2002 | 0 |
| 2003 | 0 |
| 2004 | 0 |

It should be noted that the preceding pattern for capital requirements will give conservative (higher) Life Cycle Costs than the more likely pattern of slower initial growth and accelerated growth towards the end of the development period.

h) District cooling System maintenance expenses will increase uniformly over the 25 years from \$13,200 in first year to \$330,000 in the 25th year (real 1980 dollars), i.e. about 1.5% of the ultimate capital cost of the system.

i) District Cooling System staff expenses (additional to district heating plant) will be as follows:

| Year | Real (1980) dollars/year |
|---|---|
| 1980 | 41,300.00 |
| 1 | 41,300.00 |
| 2 | 41,300.00 |
| 3 | 41,300.00 |
| 4 | 41,300.00 |
| 5 | 51,600.00 |
| 6 | 51,600.00 |
| 7 | 51,600.00 |
| 8 | 51,600.00 |
| 1990 | 61,900.00 |
| 1 | 61,900.00 |
| 2 | 61,900.00 |
| 3 | 61,900.00 |
| 4 | 61,900.00 |
| 5 | 72,300.00 |
| 6 | 72,300.00 |
| 7 | 72,300.00 |
| 8 | 72,300.00 |
| 9 | 72,300.00 |
| 2000 | 82,600.00 |
| 1 | 82,600.00 |
| 2 | 82,600.00 |
| 3 | 82,600.00 |
| 4 | 82,600.00 |

j) Cooling Plant Staff expense for individual building plants is assumed to increase every year in direct proportion to the size of the development. The annual increment for this expense is assumed at $11,200.00 (20% of the initial year energy cost).

k) Maintenance expense for individual building plants is assumed at $10,000.00 in the initial year.

l) Energy usage will increase uniformly over the 25 years for both types of systems.

m) Unit energy costs for 1980 as follows:

| | | | |
|---|---|---|---|
| Electricity - | District | $7.33/GJ | ($.02638/kwh) |
| | Individual | $12.11/GJ | ($.0436/kwh) |

n) Life Cycle Cost in terms of Present Discounted Value for 25 years is the appropriate method for economic evaluation.

o) Capital, operating and maintenance costs are derived from published reports on district heating in Ontario.

.2 Life Cycle Costs (Present Discounted Value for 25 years)

a) District Cooling System

| | | Discount Rate | |
|---|---|---|---|
| | | 2% | 6% |
| 1. | Investment | $10,976,473.00 | $ 8,042,015.00 |
| 2. | Staff | $ 1,192,892.00 | $ 760,629.00 |
| 3. | Maintenance | | |
| | $13,200 x 238.458 | 3,147,646.00 | |
| | $13,200 x 136.482 | | $ 1,801,562.00 |
| 4. | Energy - Electricity | | |
| | 4600GJ x 7.33 x 483.721 | $16,310,105.00 | |
| | 4600GJ x 7.33 x 259.695 | | $ 8,756,396.00 |
| | Total: | $31,627,116.00 | $19,360,602.00 |

b) Individual Cooling Plants

| | | 2% | 6% |
|---|---|---|---|
| 1. | Investment | | |
| | $848,000 x 19,914 | $16,887,072.00 | |
| | $848,000 x 13.550 | | $11,490,400.00 |
| 2. | Staff | | |
| | $11,200 x 238.458 | $ 2,670,730.00 | |
| | $11,200 x 136.482 | | $ 1,528,598.00 |
| 3. | Maintenance | | |
| | $10,000 x 238.458 | $ 2,384,580.00 | |
| | $10,000 x 136.482 | | $ 1,363,820.00 |
| 4. | Energy Electricity | | |
| | 4600GJ x 12.11 x 483.721 | $26,946,162.00 | |
| | 4600GJ x 12.11 x 259.695 | | $14,465,570.00 |
| | Total: | $48,888,544 | $28,849,388.00 |

## General Notes for Energy Opportunities from Municipal Waste

### 1. Residential Waste

1. Factors

a) 7100 apartment units
b) 2 people per unit
c) waste generation .1 Kg / day / person / 7 day per week
d) 10% of weight is newsprint of which half is recoverable.
e) apartment waste has heat content of 11.6 MJ/Kg
f) newspaper for recycling is currently worth $33.00 to $55.00/tonne
g) 1 tonne = 2200 lbs.

2. Total quantity / year = 5193 tonnes

3. Recoverable newsprint = 260 tonnes

4. Value $8,500 to $14,300 per year.

5. Residual waste for other energy uses 4933 tonnes.

### 2. Office Waste

1. Factors

a) 60,000 office workers.
b) 0.4 Kg / day / person (5 day / week )
c) 35% recoverable fine paper.
d) office waste has heat content of 14.0 MJ/Kg
e) fine paper for recycling is currently worth $88.00/tonne.

2. Total quantity / year = 6253 tonnes.

3. Recoverable fine paper = 2188 tonnes / year.

4. Value $192,500 per year based on $88.00 per tonne.

5. Residual waste for other energy uses 4065 tonnes / year.

3. <u>Commercial Waste</u>

1. Factors

   a) 0.5 Kg waste / $m^2$ of Gross Leasable Area / week. (Based on current Square One experience)

   b) Ultimate Gross Leasable Area - 353,000 $m^2$

   c) 20% of waste recoverable in form of corrugated cardboard.

   d) commercial waste heat value assume same as residential 11.6 MJ /Kg.

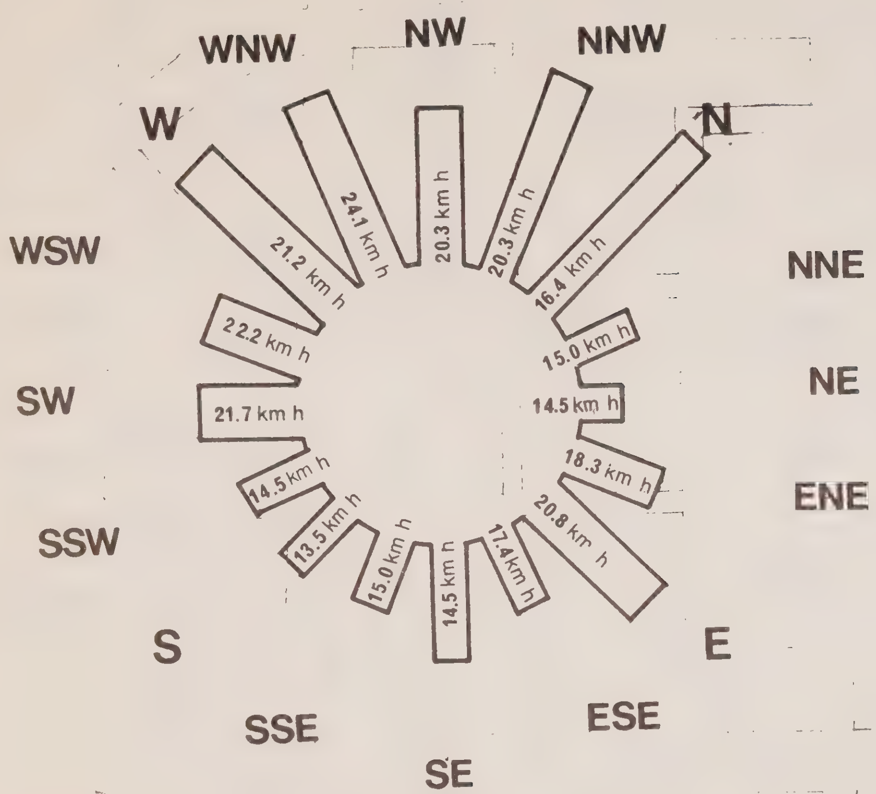
   e) corrugated cardboard for recycling is currently worth \$88.00 to \$110.00 / tonne.

2. Total quantity / year = 9178 tonnes.

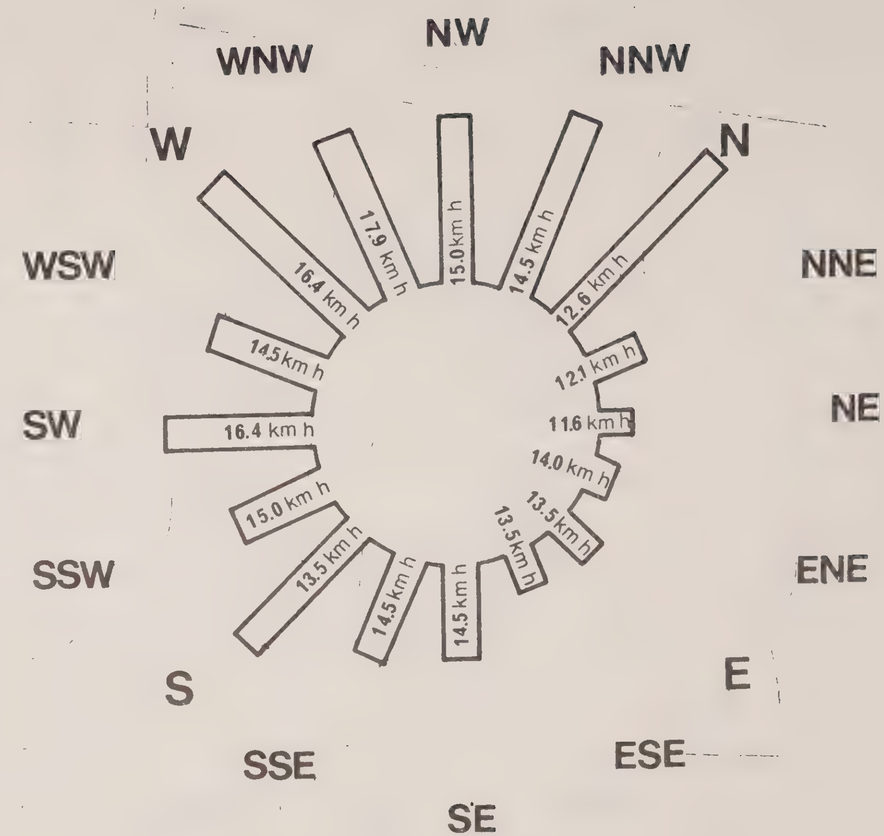
3. Recoverable corrugated cardboard = 1835 tonnes

4. Value \$161,480 to \$201,850 / year.

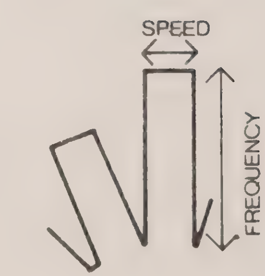
5. Residue for other energy uses 7343 tonnes.




APRIL

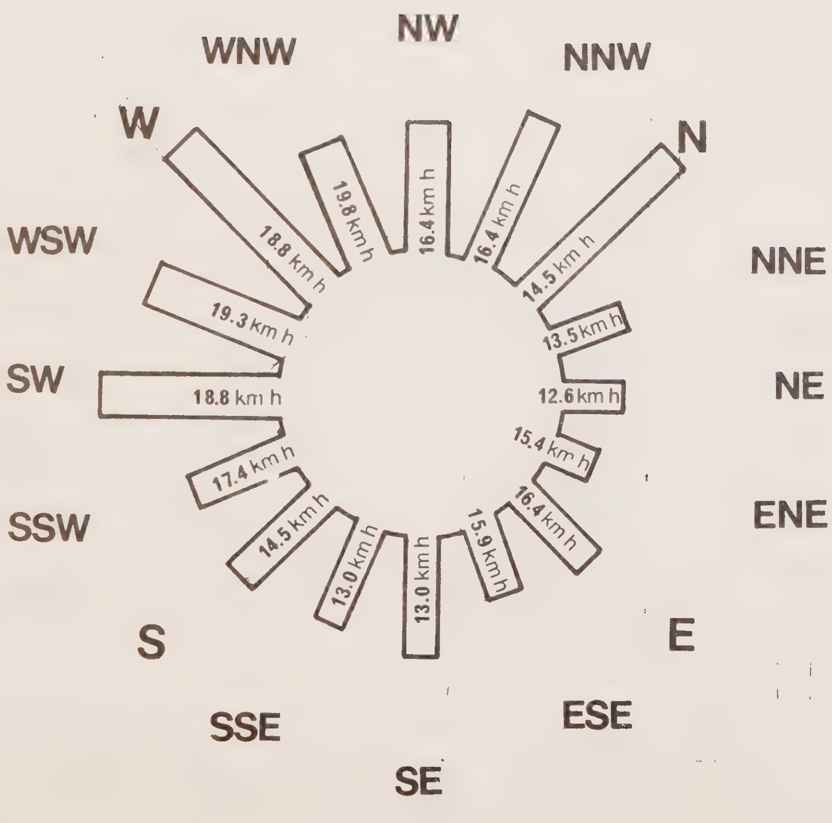



JULY

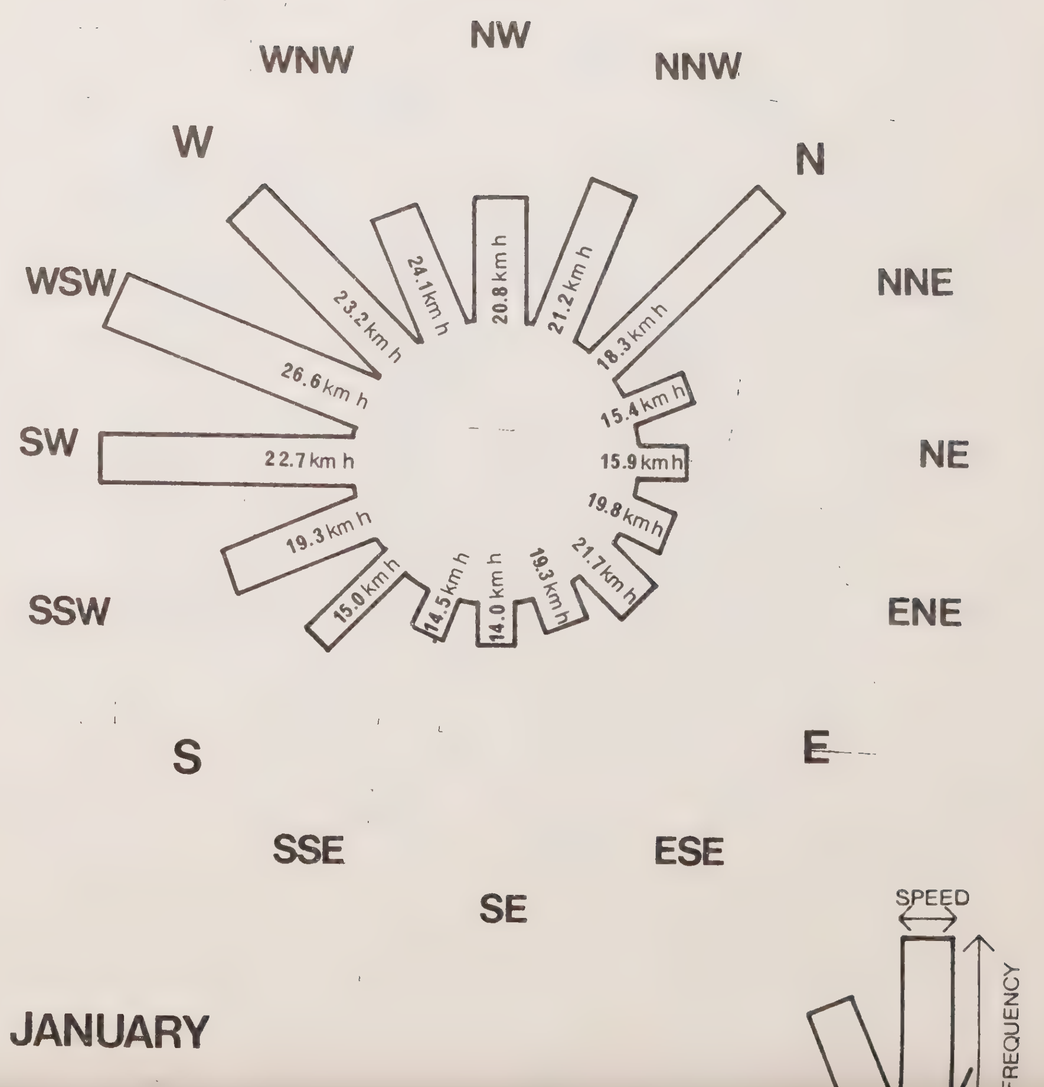



WIND ROSES

Appendix VIII.




OCTOBER




JANUARY

# TORONTO (INT'L A), ONT.

PERIOD 1955-72 PÉRIODE HEIGHT OF ANEMOMETER 33' HAUTEUR DE L'ANÉMOMÈTRE

PERCENTAGE FREQUENCY / FRÉQUENCE EN %

| | JAN JANV | FEB FEV | MAR MARS | APR AVR | MAY MAI | JUN JUIN | JUL JUIL | AUG AOUT | SEP SEPT | OCT OCT | NOV NOV | DEC DEC | YEAR ANNUEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 12 | 12 | 13 | 11 | 11 | 11 | 11 | 11 | 11 | 10 | 8 | 10 | 11 | N |
| NNE | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | NNE |
| NE | 3 | 3 | 4 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 3 | NE |
| ENE | 2 | 3 | 4 | 4 | 2 | 1 | 1 | 1 | 2 | 2 | 3 | 4 | 2 | ENE |
| E | 3 | 4 | 7 | 8 | 5 | 3 | 2 | 3 | 4 | 5 | 4 | 4 | 4 | E |
| ESE | 2 | 2 | 3 | 4 | 3 | 2 | 2 | 2 | 3 | 4 | 4 | 3 | 3 | ESE |
| SE | 2 | 2 | 3 | 6 | 6 | 6 | 5 | 5 | 6 | 6 | 5 | 3 | 4 | SE |
| SSE | 2 | 2 | 2 | 4 | 7 | 7 | 6 | 6 | 5 | 5 | 3 | 2 | 4 | SSE |
| S | 5 | 6 | 4 | 4 | 7 | 8 | 8 | 6 | 7 | 6 | 6 | 6 | 6 | S |
| SSW | 7 | 5 | 4 | 3 | 3 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | SSO |
| SW | 12 | 8 | 5 | 5 | 7 | 7 | 7 | 8 | 7 | 9 | 9 | 10 | 8 | SO |
| WSW | 13 | 8 | 5 | 5 | 6 | 6 | 6 | 7 | 6 | 7 | 11 | 10 | 8 | OSO |
| W | 11 | 12 | 11 | 10 | 8 | 10 | 10 | 11 | 10 | 10 | 12 | 11 | 11 | O |
| WNW | 6 | 7 | 9 | 9 | 7 | 7 | 8 | 7 | 6 | 6 | 7 | 6 | 7 | ONO |
| NW | 6 | 9 | 8 | 8 | 7 | 7 | 8 | 9 | 7 | 6 | 6 | 6 | 7 | NO |
| NNW | 8 | 10 | 10 | 10 | 10 | 9 | 9 | 9 | 9 | 8 | 7 | 8 | 9 | NNO |
| Calm | 3 | 4 | 4 | 4 | 5 | 6 | 7 | 6 | 6 | 5 | 4 | 4 | 5 | Calme |

AVERAGE WIND SPEED IN MILES PER HOUR / VITESSE MOYENNE DES VENTS EN MILLES/HEURE

| | JAN JANV | FEB FEV | MAR MARS | APR AVR | MAY MAI | JUN JUIN | JUL JUIL | AUG AOUT | SEP SEPT | OCT OCT | NOV NOV | DEC DEC | YEAR ANNUEL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | 10.4 | 10.3 | 9.8 | 9.3 | 9.7 | 8.7 | 7.5 | 7.7 | 7.8 | 8.1 | 8.8 | 9.7 | 9.0 | N |
| NNE | 8.7 | 8.9 | 8.9 | 8.6 | 7.7 | 7.6 | 6.9 | 7.3 | 7.9 | 7.9 | 8.1 | 8.5 | 8.1 | NNE |
| NE | 8.9 | 8.7 | 8.7 | 8.2 | 6.9 | 6.1 | 6.6 | 7.0 | 6.2 | 6.9 | 7.8 | 9.2 | 7.6 | NE |
| ENE | 10.9 | 11.5 | 11.3 | 10.4 | 9.2 | 8.3 | 8.2 | 6.8 | 7.1 | 8.6 | 9.0 | 10.4 | 9.3 | ENE |
| E | 12.5 | 12.2 | 13.1 | 12.1 | 9.8 | 9.0 | 7.9 | 8.3 | 8.5 | 9.4 | 9.9 | 11.9 | 10.4 | E |
| ESE | 11.4 | 11.2 | 11.9 | 10.1 | 9.1 | 8.0 | 7.9 | 8.1 | 8.4 | 9.1 | 9.8 | 11.2 | 9.7 | ESE |
| SE | 8.1 | 7.7 | 7.3 | 8.3 | 7.8 | 7.5 | 8.0 | 7.8 | 7.6 | 7.8 | 7.9 | 8.2 | 7.8 | SE |
| SSE | 7.7 | 7.6 | 7.8 | 8.5 | 8.1 | 7.8 | 8.4 | 8.1 | 7.6 | 7.5 | 8.2 | 7.2 | 7.9 | SSE |
| S | 8.4 | 8.4 | 7.5 | 7.5 | 7.5 | 6.8 | 7.3 | 7.2 | 7.7 | 7.7 | 9.1 | 8.4 | 7.8 | S |
| SSW | 10.7 | 10.5 | 11.1 | 10.7 | 9.5 | 8.4 | 8.4 | 7.9 | 10.0 | 9.9 | 11.0 | 10.0 | 9.8 | SSO |
| SW | 12.6 | 11.0 | 13.2 | 12.3 | 11.1 | 9.6 | 9.1 | 9.2 | 10.5 | 10.6 | 13.0 | 12.3 | 11.2 | SO |
| WSW | 14.9 | 13.3 | 13.1 | 12.7 | 11.6 | 10.6 | 9.1 | 9.3 | 9.8 | 10.8 | 14.3 | 13.4 | 11.9 | OSO |
| W | 13.1 | 13.3 | 12.8 | 12.3 | 11.0 | 9.9 | 9.4 | 8.6 | 9.3 | 10.6 | 13.1 | 13.0 | 11.4 | O |
| WNW | 13.9 | 13.2 | 13.3 | 14.0 | 12.6 | 10.1 | 10.1 | 9.7 | 10.0 | 11.2 | 13.1 | 13.3 | 12.0 | ONO |
| NW | 11.9 | 13.1 | 11.4 | 11.3 | 10.4 | 8.6 | 8.5 | 8.3 | 8.8 | 9.5 | 11.1 | 11.1 | 10.3 | NO |
| NNW | 12.1 | 12.8 | 11.8 | 11.6 | 10.5 | 9.6 | 8.1 | 8.5 | 9.0 | 9.7 | 11.5 | 11.4 | 10.6 | NNO |
| All Directions | 11.4 | 11.1 | 10.9 | 10.4 | 9.3 | 8.3 | 7.8 | 7.8 | 8.2 | 8.8 | 10.6 | 10.7 | 9.6 | Toutes directions |

| | | |
|---|---|---|
| Maximum Observed Hourly Speed | 55 SW | Vitesse horaire maximale observée |
| Maximum Observed Gust Speed | 84 | Vitesse maximale observée des rafales |
| Probable Maximum Gust for Maximum Hourly Speed | 77 | Rafale maximale en rapport avec vitesse maximale des vents horaires |

## STATION INFORMATION

Station is located on the slightly rolling to flat terrain. Nearby to the west is a small valley containing the Etobicoke Creek. Most of surrounding countryside is open on which occasional trees are found. The shore of Lake Ontario is about 8 miles southeast and main metropolitan area is several miles east.

## DONNÉES RELATIVES À LA STATION

La station se trouve sur un terrain plat ou légèrement accidenté. A l'ouest, tout près, un vallon conduit à Etobicoke Creek. La majeure partie de la région environnante est dégagée et ne porte que quelques arbres. La rive du lac Ontario commence à 8 milles au sud-est et le coeur de la ville, à plusieurs milles à l'est.

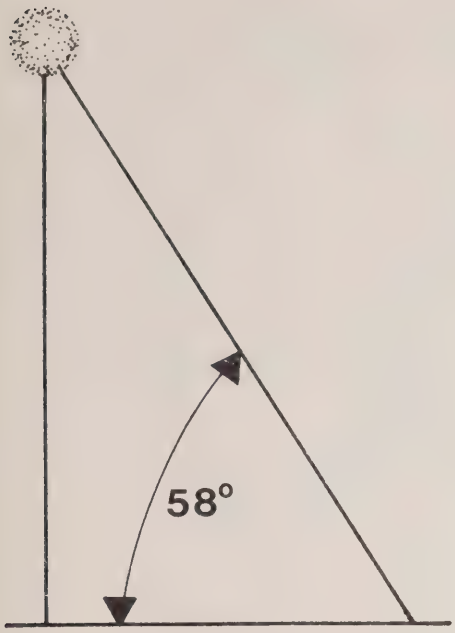
Extract from: Canadian Normals, Wind Vol. 3 1955-1975 Environment Canada.

SUN ANGLES

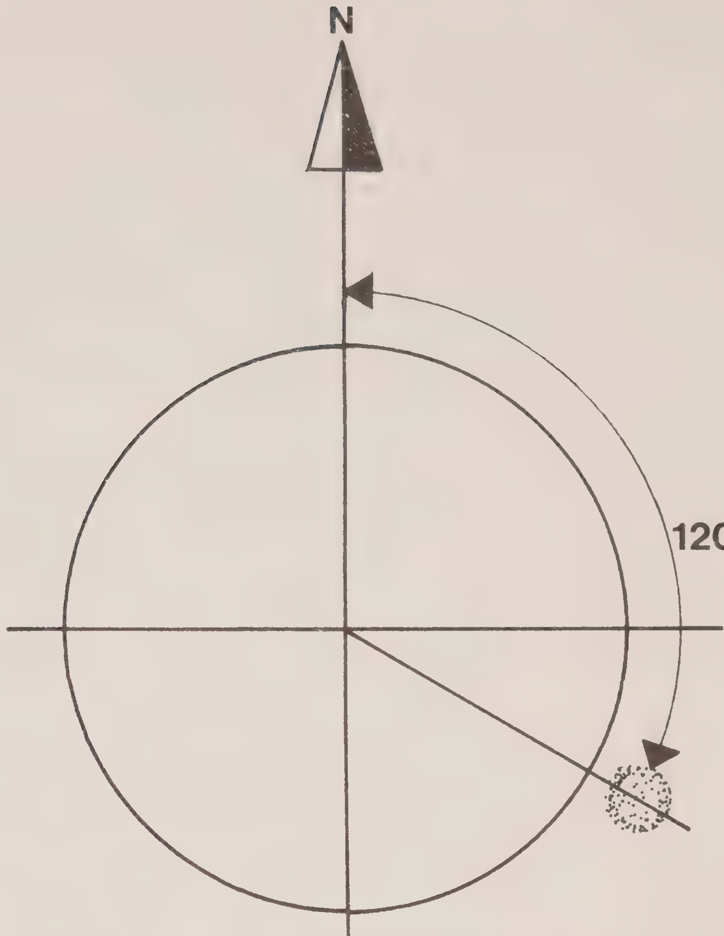
TORONTO - 44°N LATITUDE

| | | ALTITUDE | AZIMUTH |
|---|---|---|---|
| March 21* - | 10 a.m. | 38.5° | 140° |
| | 11 a.m. | 44° | 160° |
| | 12 noon | 46° | 180° |
| April 16* - | 10 a.m. | 47 | 132 |
| | 11 a.m. | 54 | 155 |
| | 12 noon | 56 | 180 |
| May 20 - | 11 a.m. | 55 | 125 |
| | 12 noon | 63 | 148 |
| | 1 p.m. | 66 | 180 |
| June 21 - | 11 a.m. | 58 | 120 |
| | 12 noon | 66 | 145 |
| , | 1 p.m. | 69.5 | 180 |
| July 23 - | 11 a.m. | 55 | 125 |
| | 12 noon | 63 | 148 |
| | 1 p.m. | 66 | 180 |
| Aug. 27 - | 11 a.m. | 47 | 132 |
| | 12 noon | 54 | 155 |
| | 1 p.m. | 56 | 180 |
| Sept. 23 - | 11 a.m. | 38.5 | 140 |
| | 12 noon | 44 | 160 |
| | 1 p.m. | 46 | 180 |

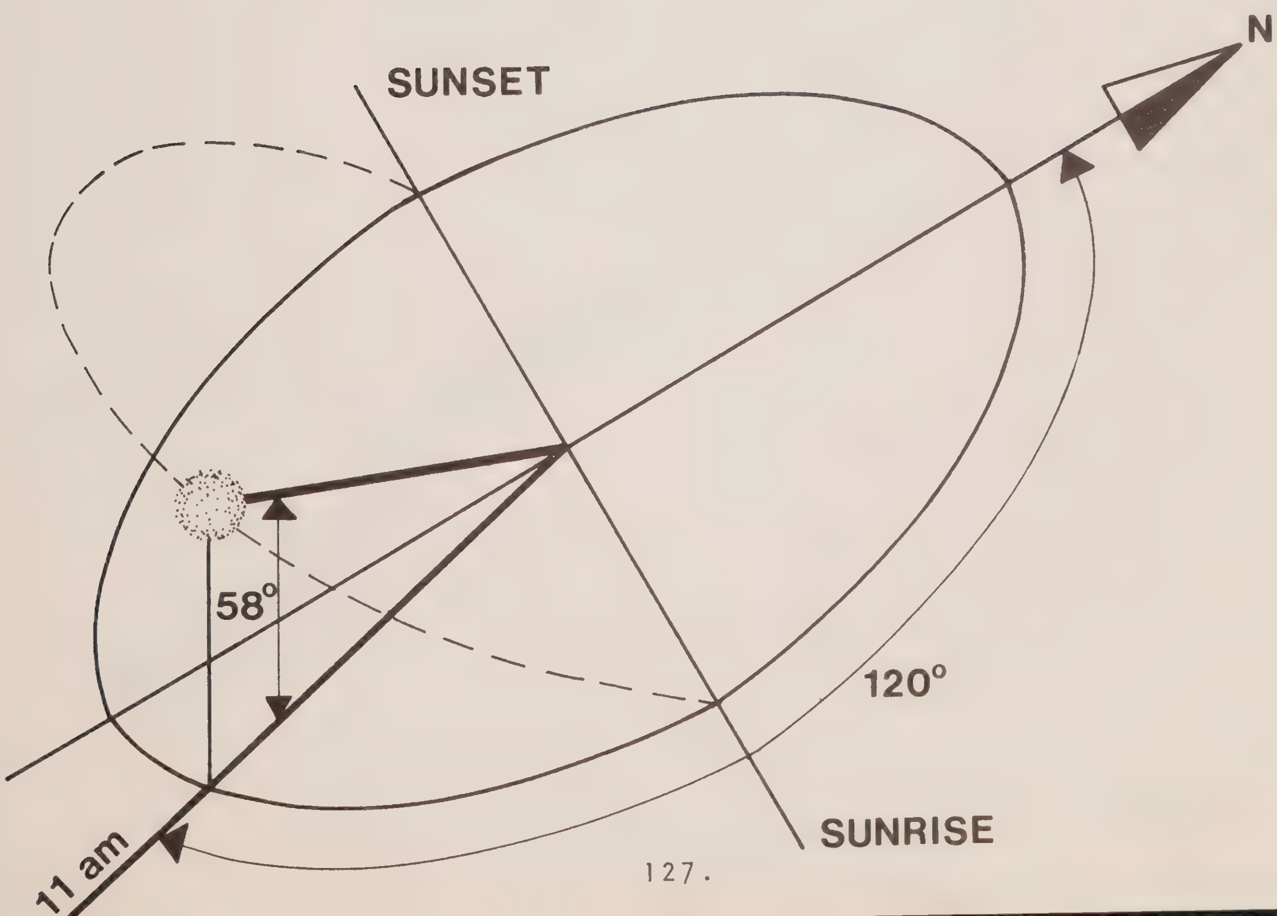
* adjusted for day light savings time.




ELEVATION
(ALTITUDE)




PLAN (AZIMUTH)



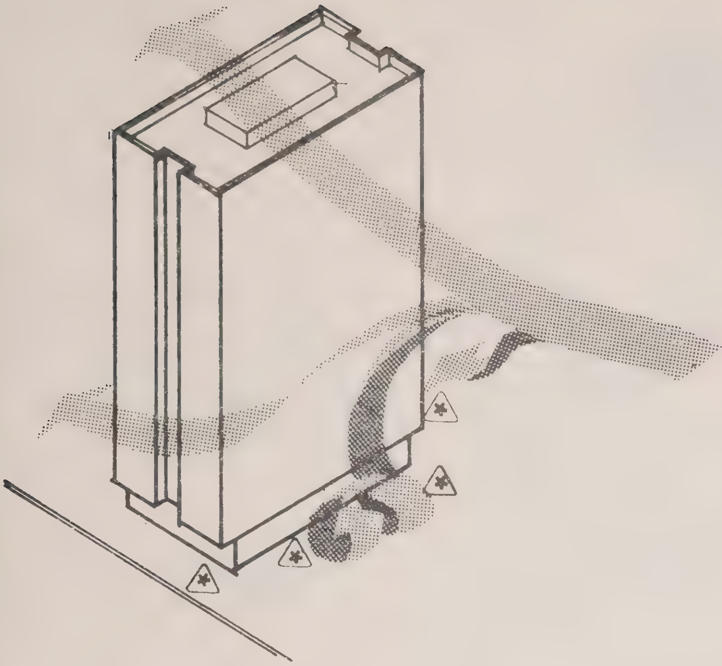
## <u>LOCALIZED MODIFICATION OF MICROCLIMATE BY VARIOUS BUILDING MASSES.</u>

- In the following sketches, which show some of the known wind effects on buildings, $\triangle$ indicates an area which will be adversely affected by the wind direction shown. Conversely, a comfortable pedestrian area is indicated by $\circledast$

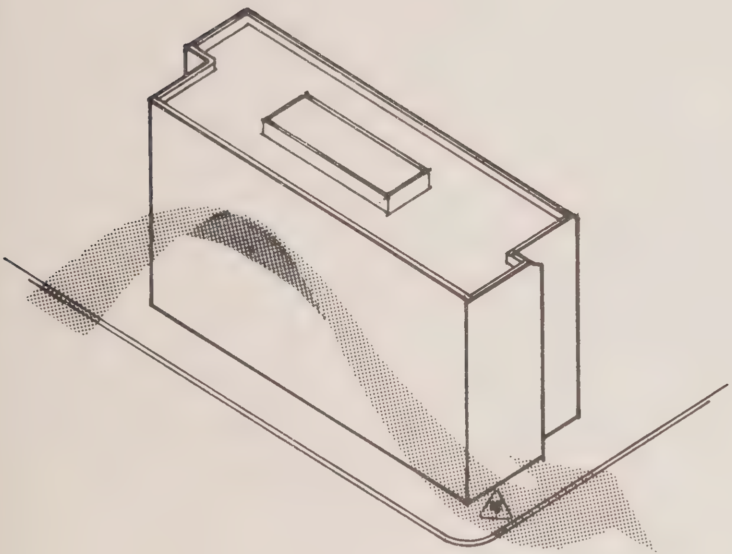
- The wind effects shown will alter, in some cases drastically, when surrounding buildings are added. The information should, therefore, only be used for conceptual planning. Detailed scale model studies are the only acceptable method of obtaining quantitative information on the pedestrian level wind speeds around buildings.

- Relative dimensions of building forms to create the shown wind flows can be inferred from the sketches. Exact dimensions will, of course, depend on the surrounding buildings.

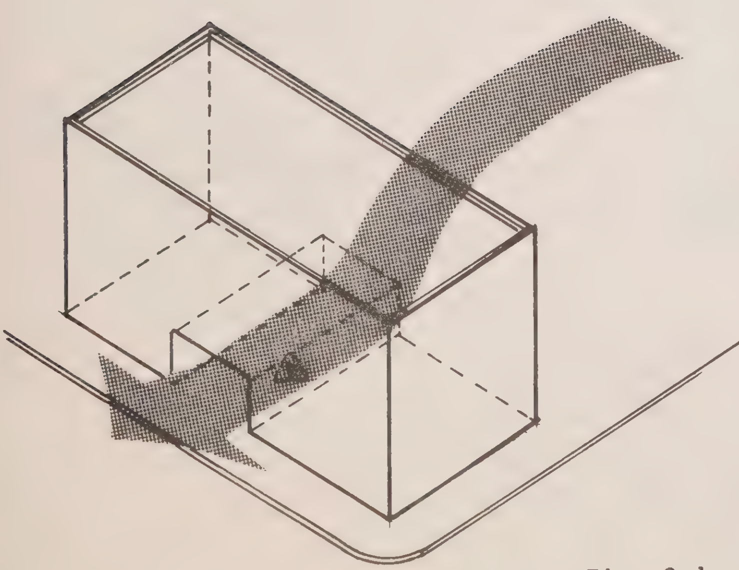
Appendix IX.



a) This effect is magnified as building height increases.

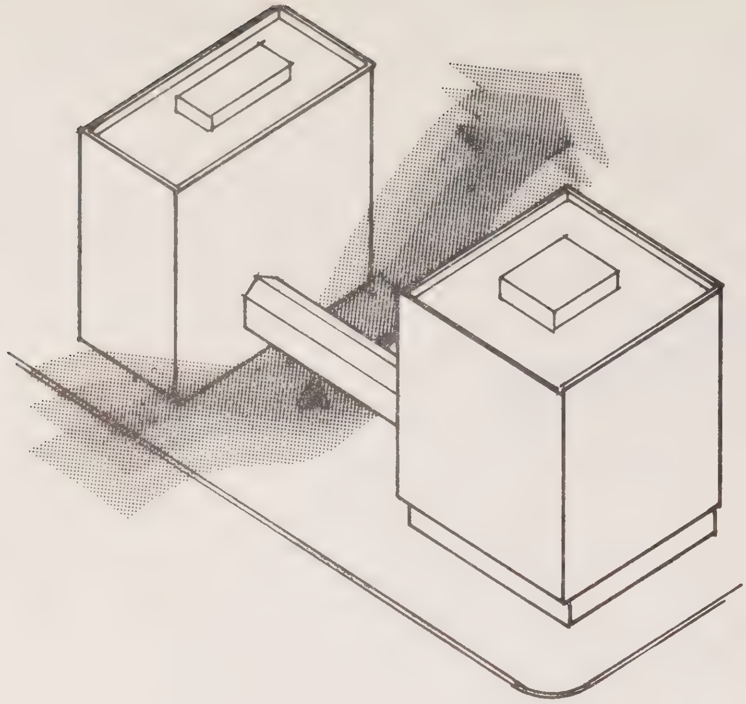


b) Wind flowing at an angle to a long (and tall) building will be concentrated at the downwind corner of the building. The longer the building the greater the increase in pedestrian level wind speed.

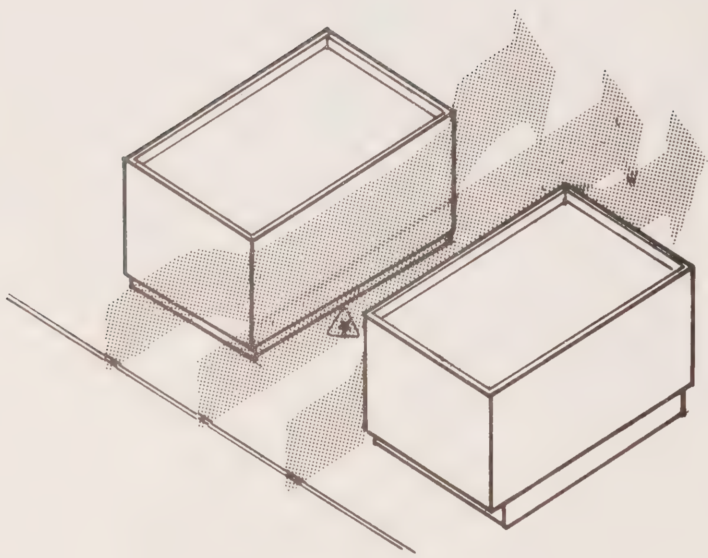


c) An open passageway through a tall building creates and uncomfortable condition in the passageway and reduces the sheltered condition behind the building.

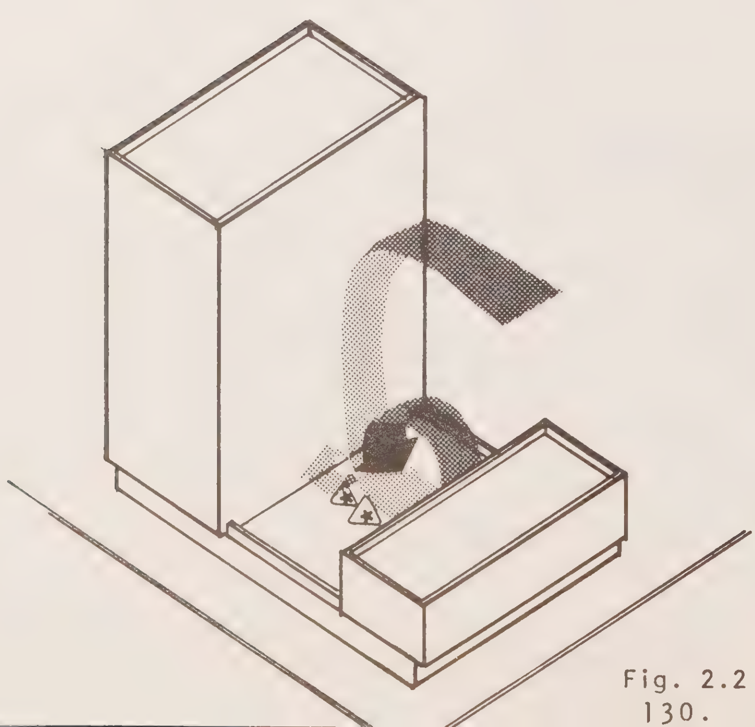
Fig. 2.1



a) + 15 level walkways can further increase already accelerated wind flows.

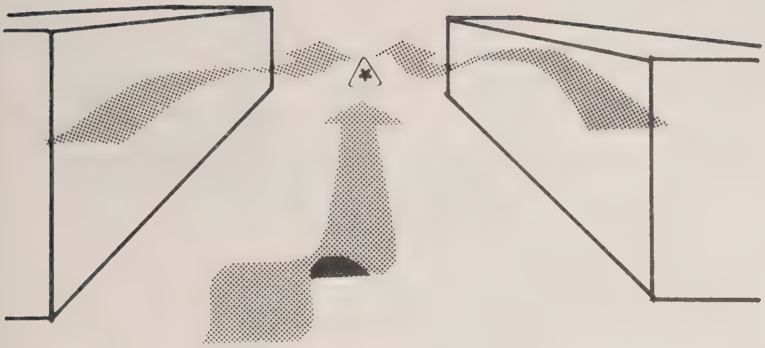


b) This creates a very severe pedestrian level wind condition.

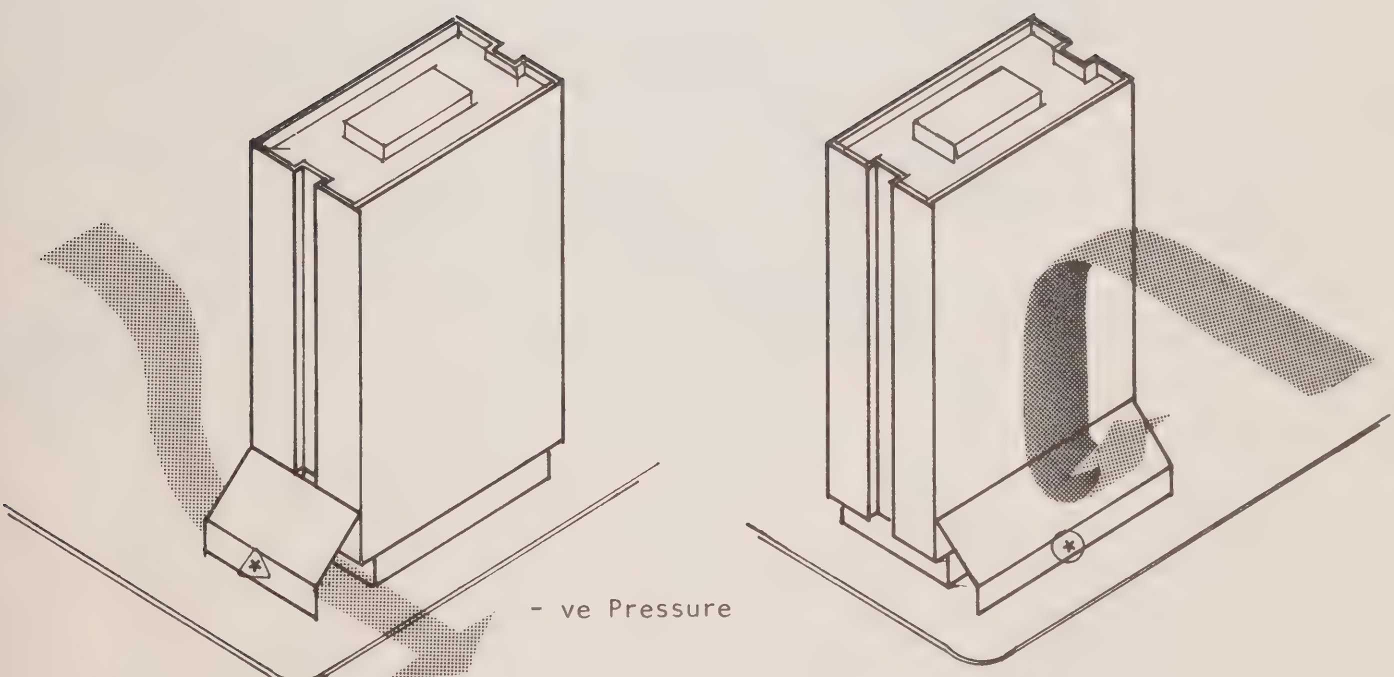


c) Locating a low rise building upstream of a highrise can cause more wind to be deflected down the face of the tall building.

Fig. 2.2

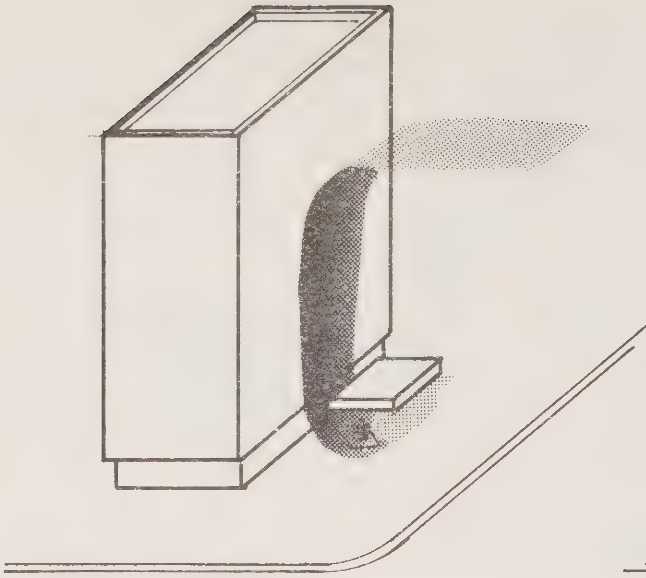


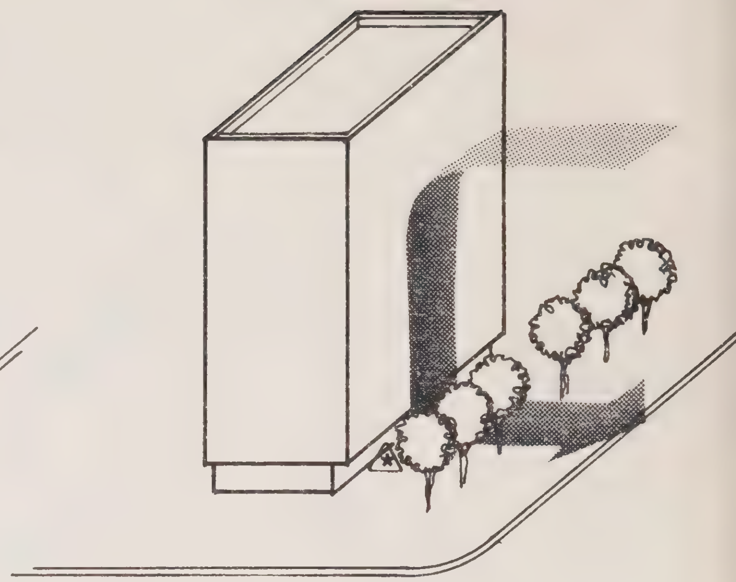
a) Wind can also be funneled by relatively low buildings.




b) Enclosed passageways should connect areas of equal pressure.

Fig. 2.3

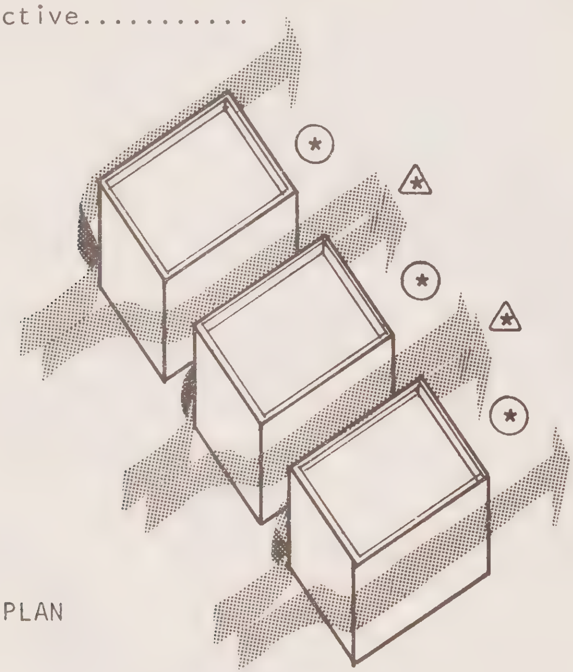




ELEVATION

a) A canopy which is not touching a building is ineffective..........

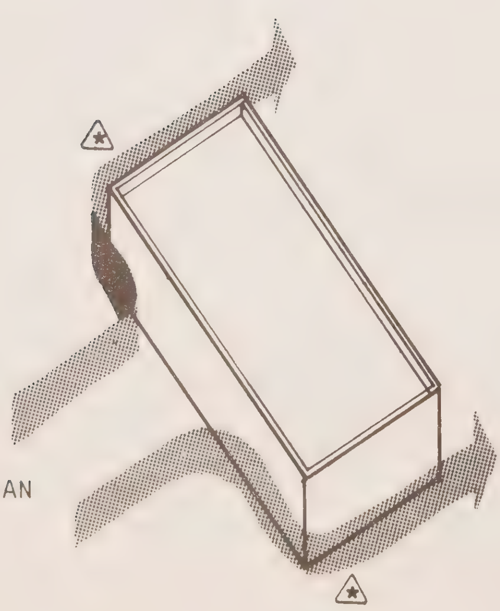
b) .....also landscaping



PLAN

c) Produces an alternating calm/windy sensation - uncomfortable .......

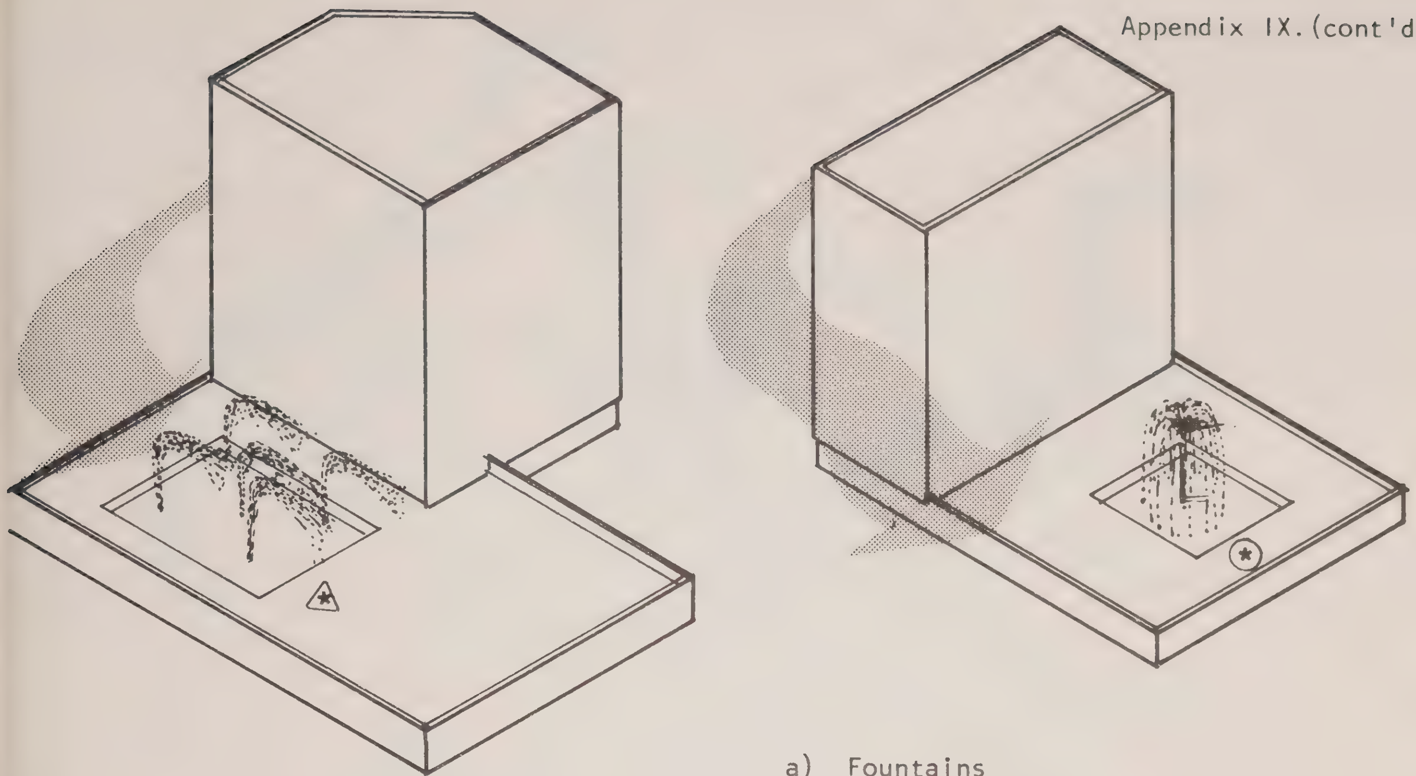
BUT



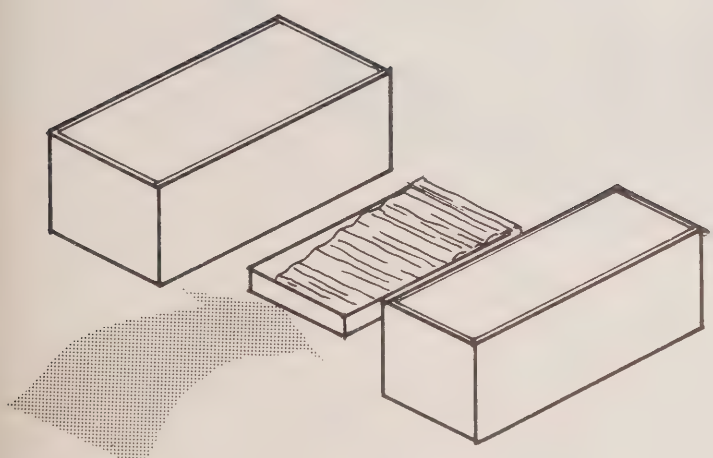
PLAN

d) .... This produces relatively highe wind speeds.

Fig. 2.4



a) Fountains



b) Ponds

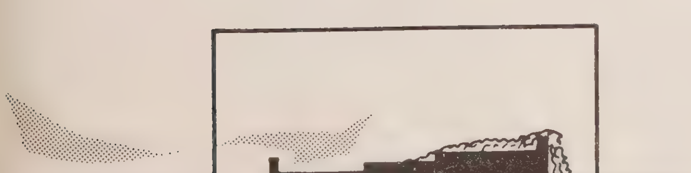
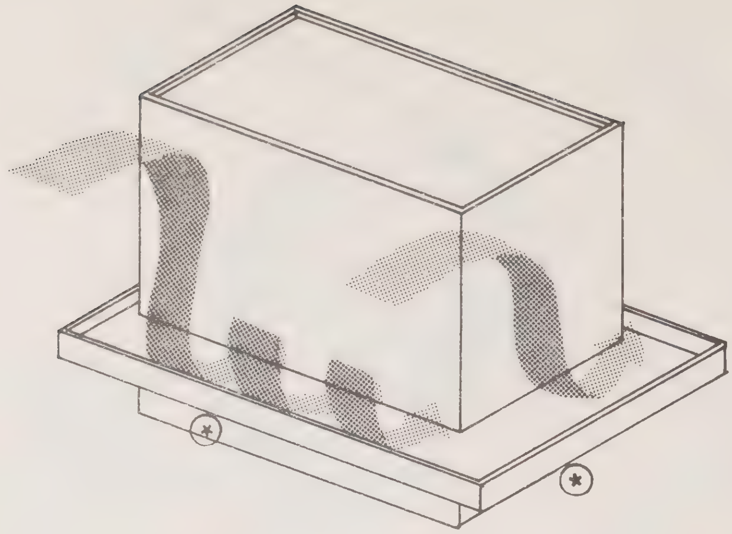
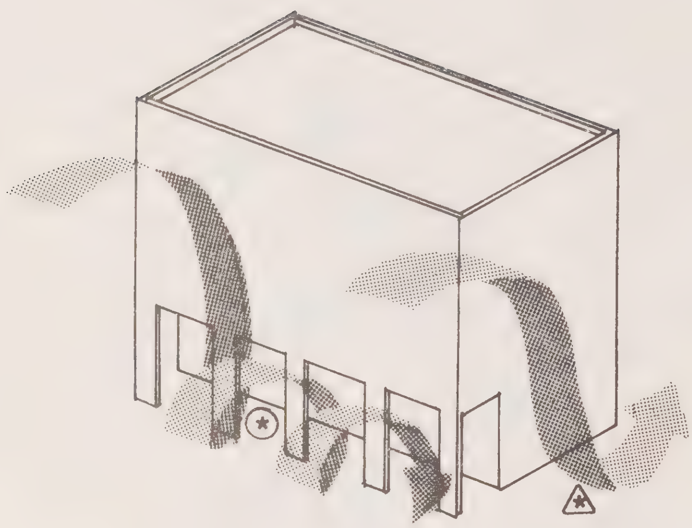


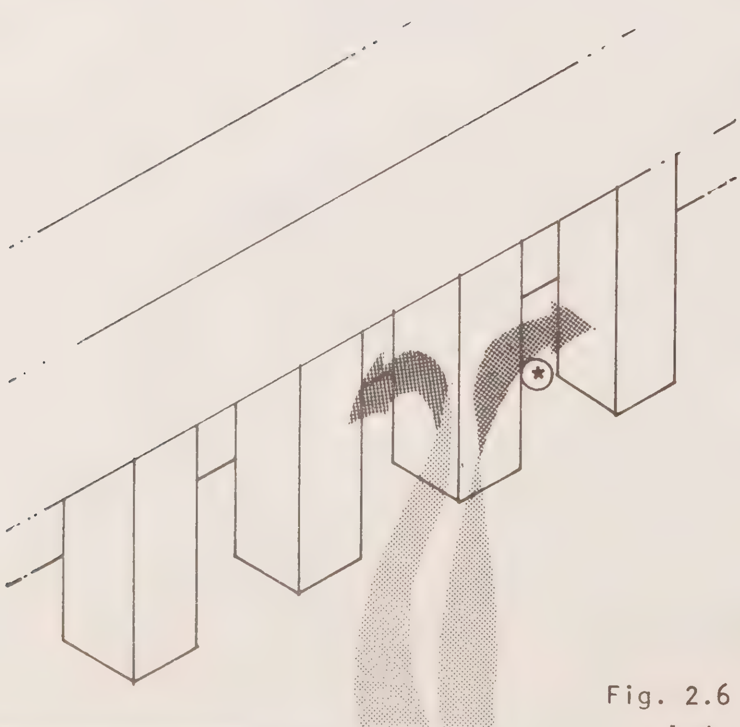
Fig. 2.5



a) Canopies are beneficial on the windward face and should be continued around the building.
-- parapet walls assist

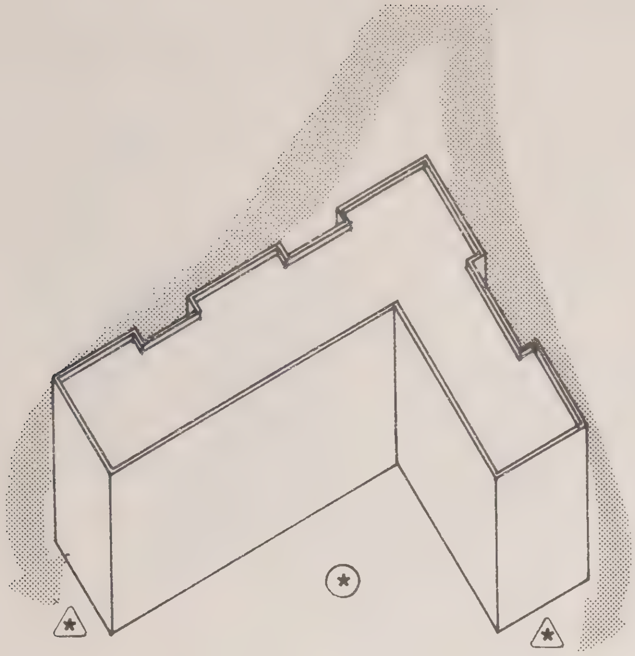


b) Arcades have a similar effe

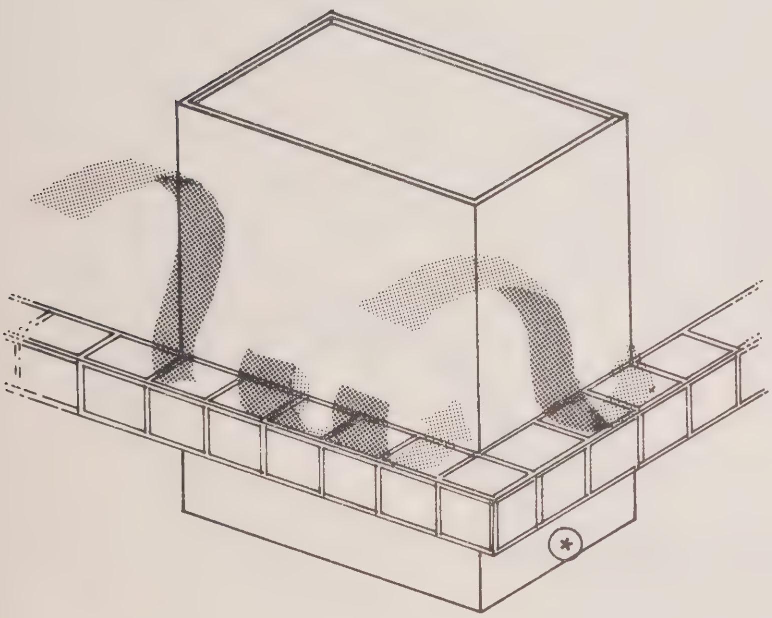


c) Large columns assist with angled flows.

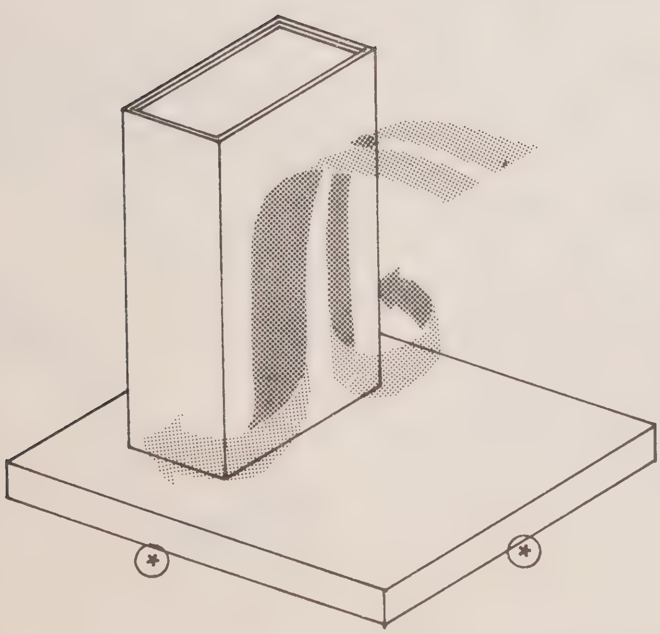
Fig. 2.6



a) Building can be used as windscreens but pedestrian areas should be carefully selected.

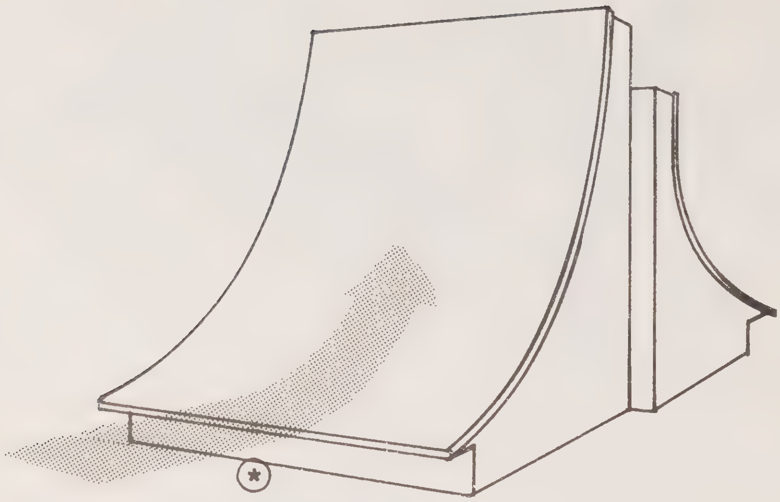


b) +15 feet level walkways can be used as canopies.

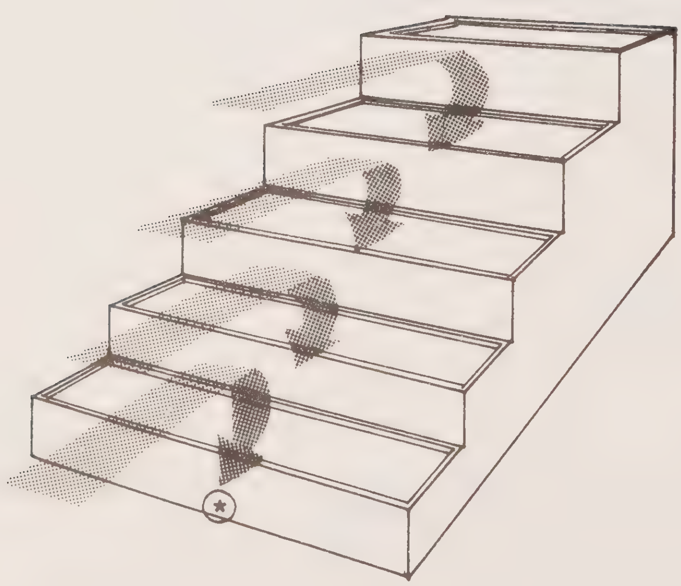


c) Non-pedestrian podiums provide comfortable walkways around tall buildings.

Fig. 2.7

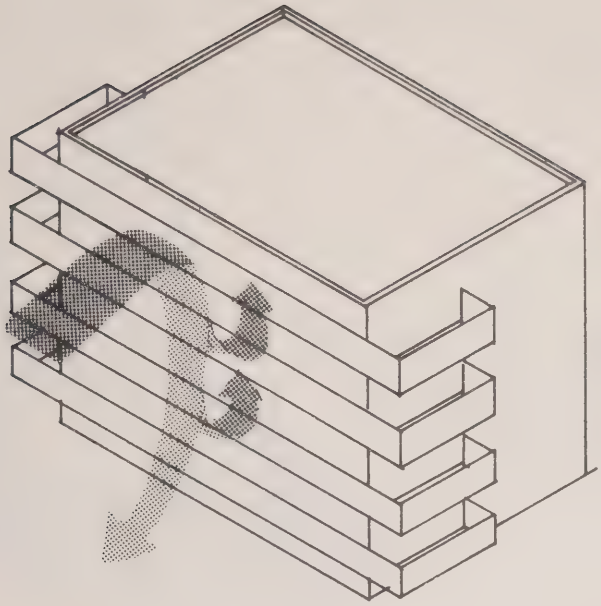


b) Curved faces can prevent the downwash effect.



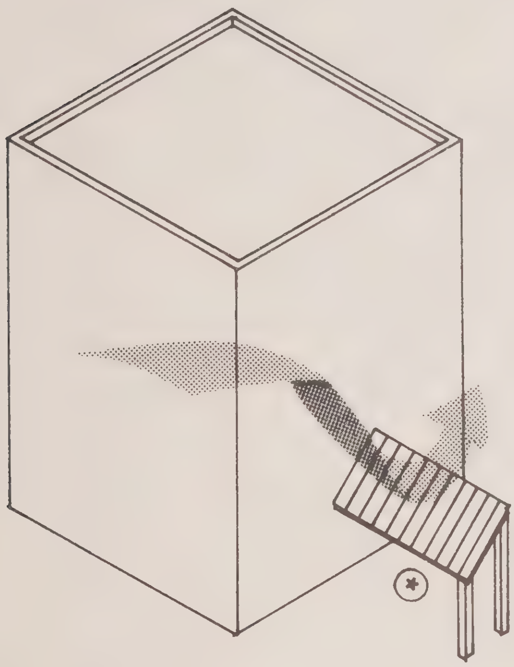
a) Stepped buildings will gradually break up approaching wind flows.

Fig. 2.8

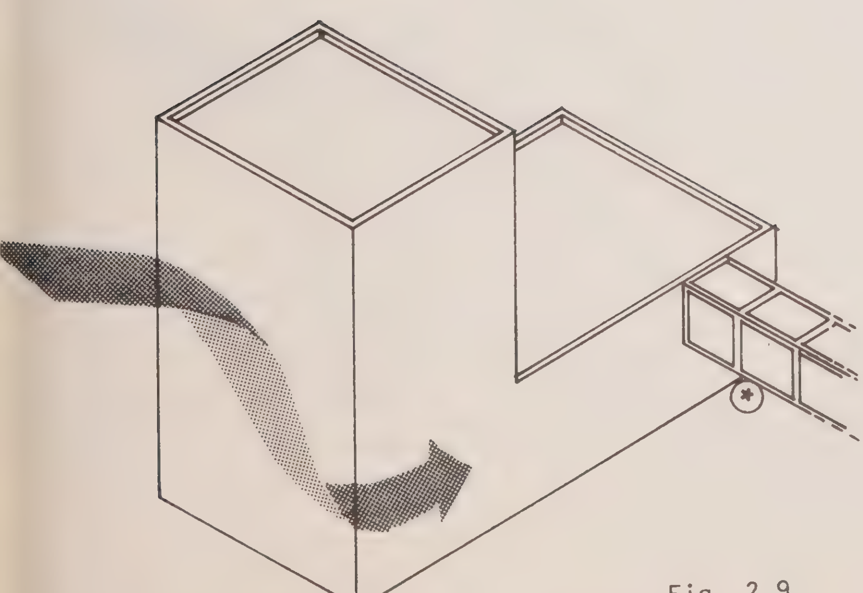


a) Balconies can minimize. but not prevent downwash.

Elevation

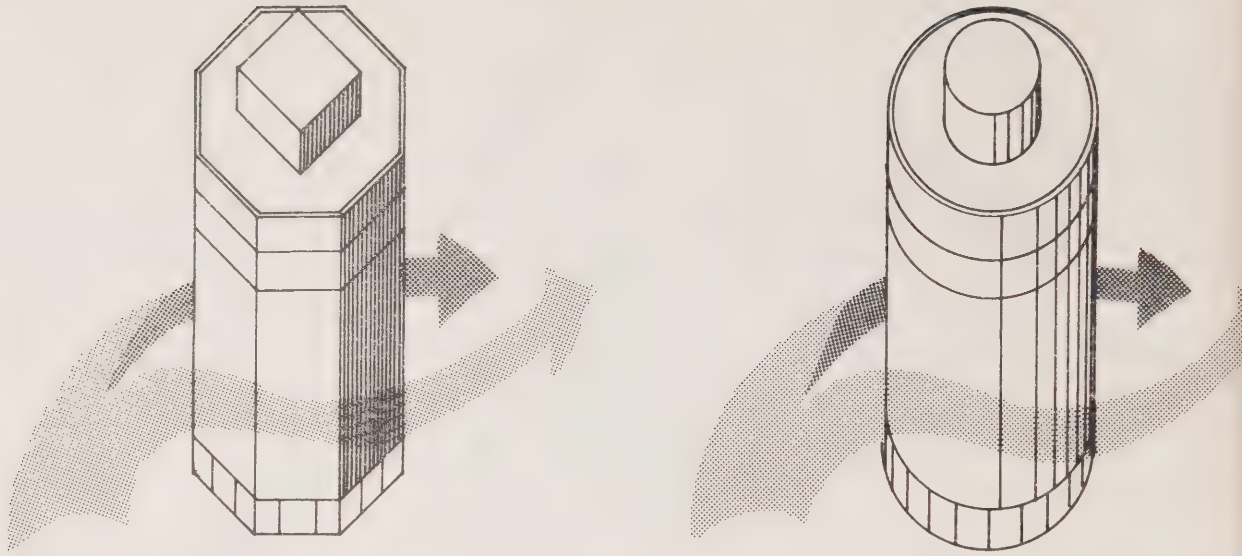


b) A wind deflector fin if carefully designed, can minimize corner wind flows.

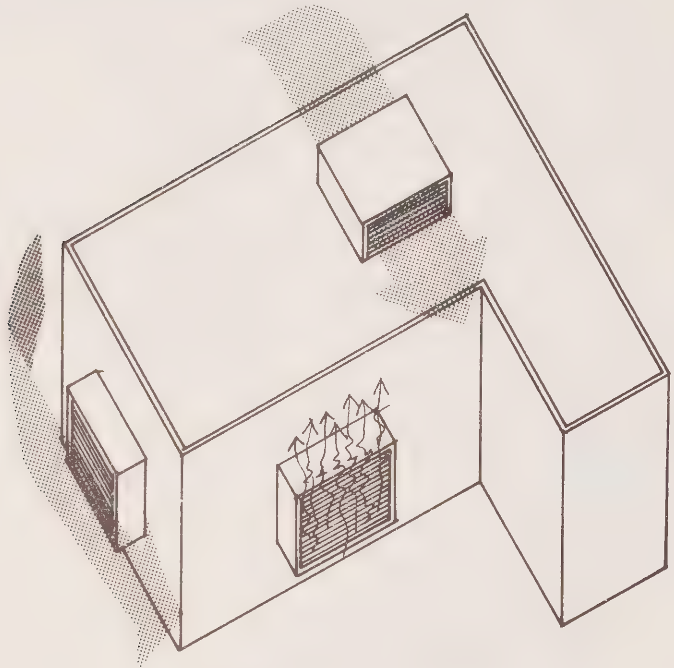


c) +15 feet walkways should be located away from increased corner flows.

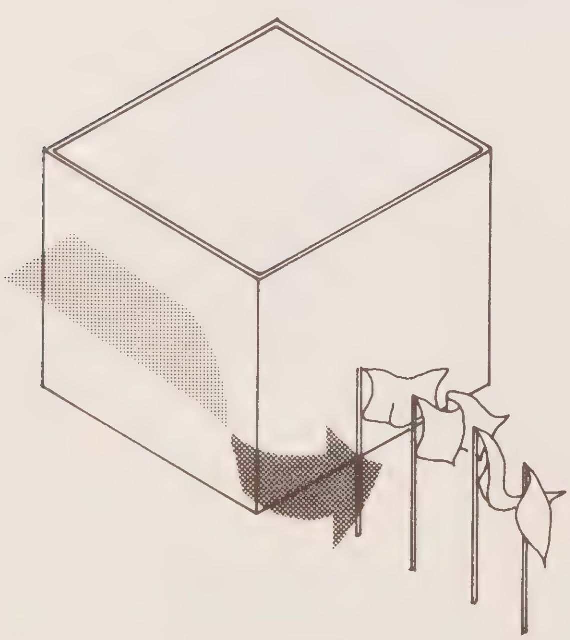
Fig. 2.9



a) Round and hexagonal shape
buildings minimize downwa

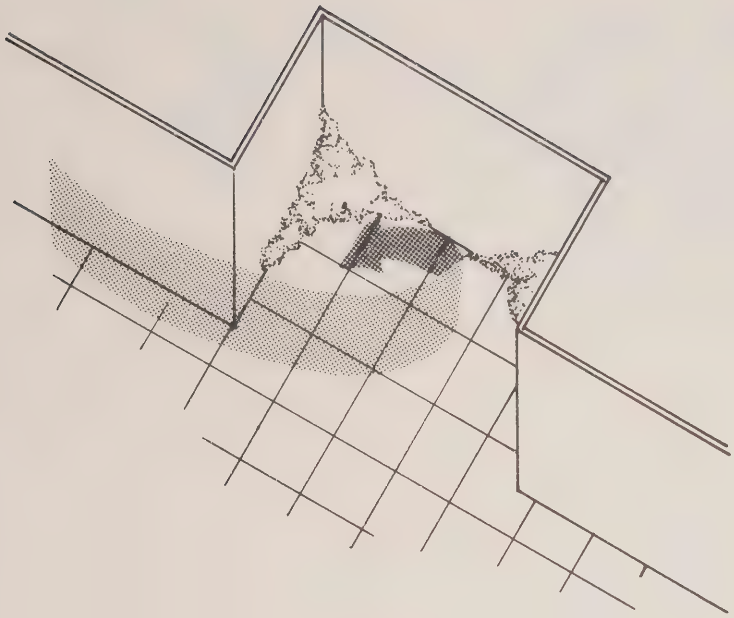


b) Locate mechanical exhaust
in wind flows - not
stagnant air regions.

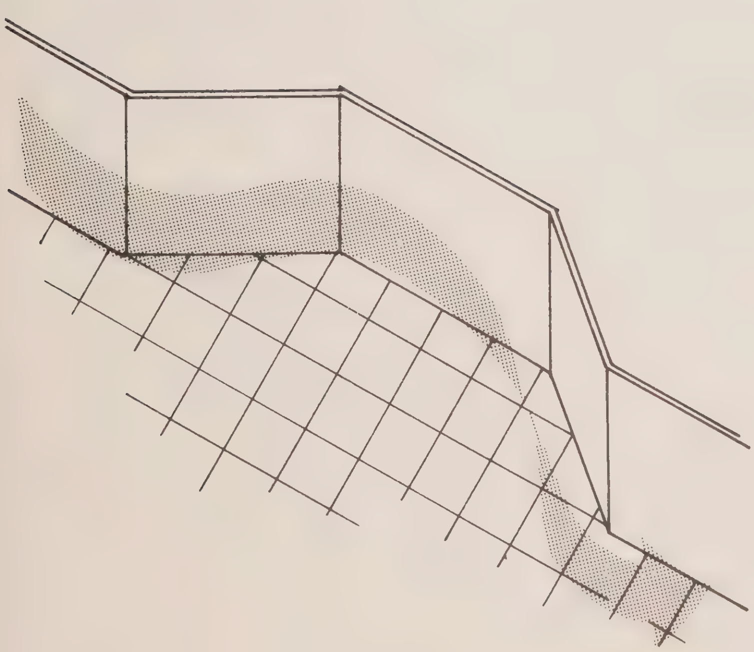


c) Provide public indicators
of wind conditions in
unavoidable high wind
speed areas e.g. flags.

Fig. 2.10

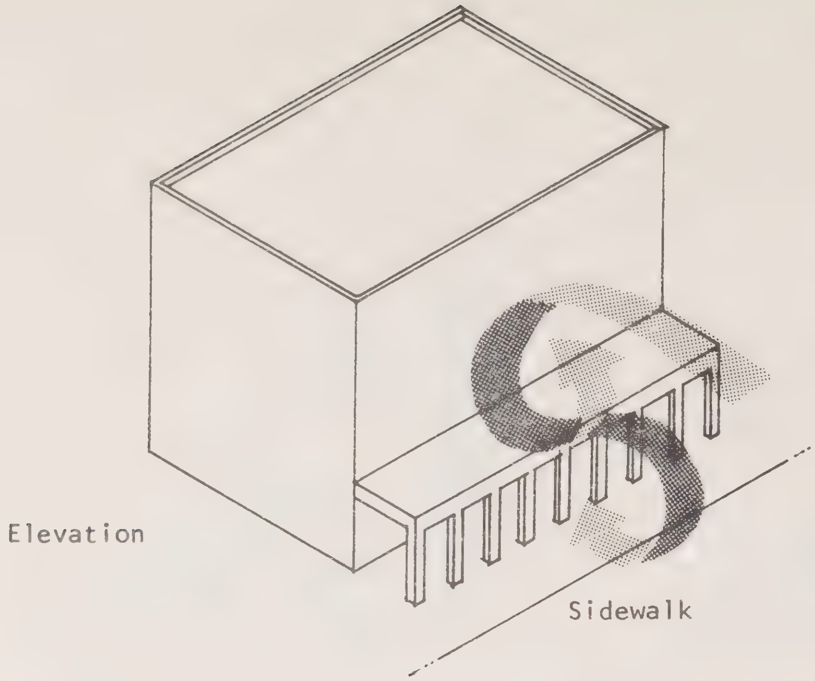


a) "Over protected" entrance. Recessed entrances with still air regions are potential snow collection areas.



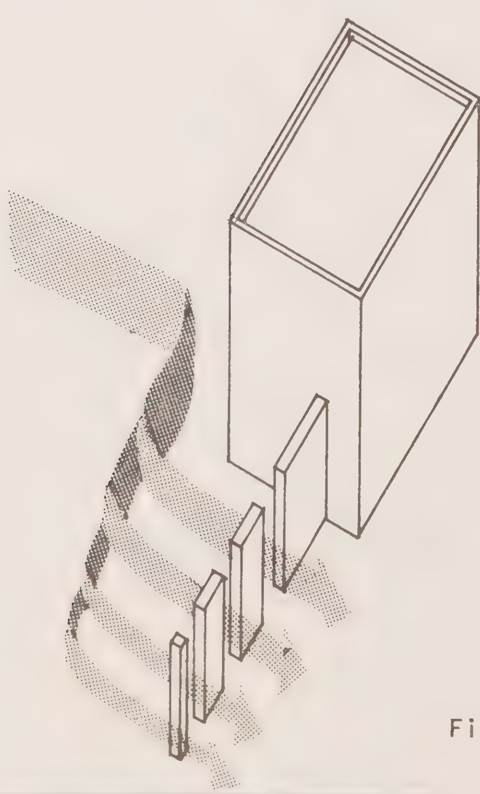
b) Scoured entrance.

Fig. 2.11



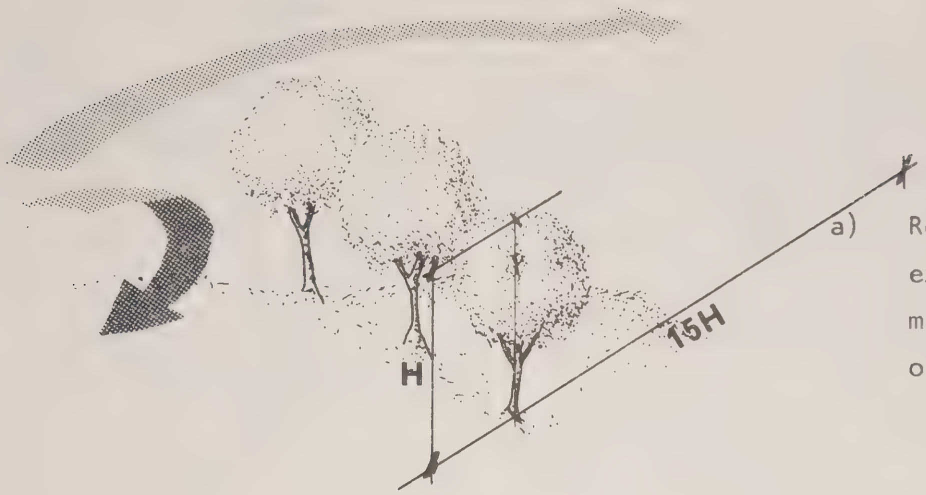

a) Give pedestrians a choice of calm or windy areas (breezes are welcome on hot days).


b) Recessed lounging areas are desirable.

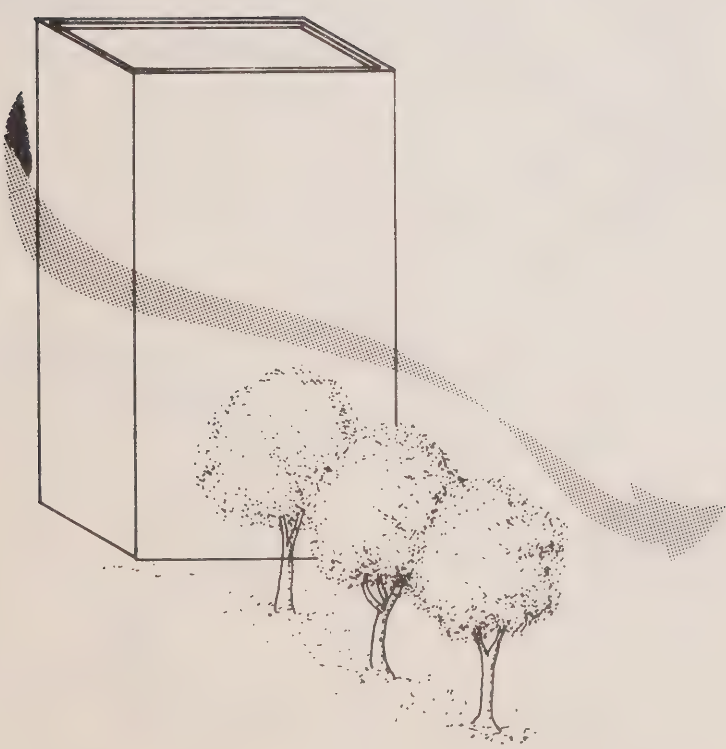


c) If a windy area is unavoidable, introduce pedestrian to the high wind speed area gradually i.e. baffles break up winc

Fig. 2.12

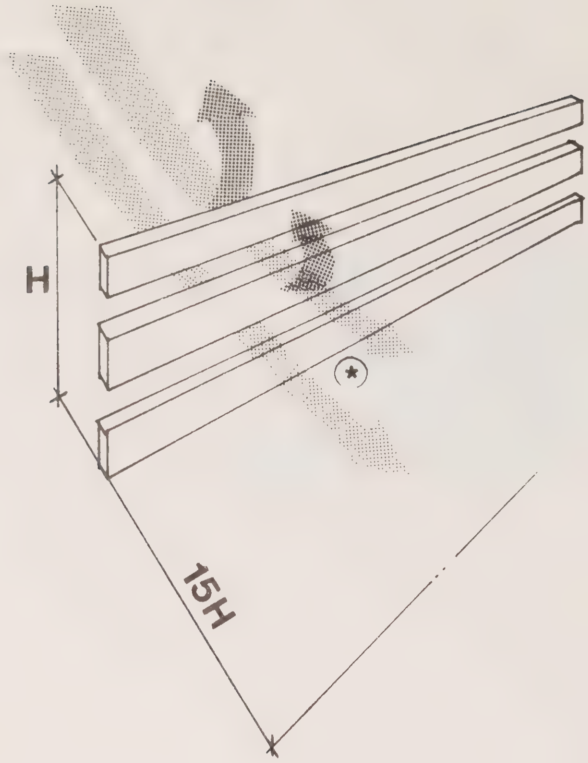



a) Reduced velocity area exists for approximately 15 x height of trees.

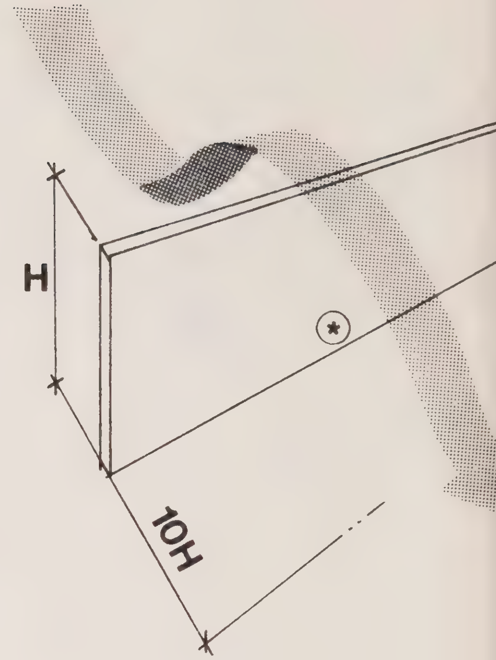


b) Downwash from a building can shorten this protected area.

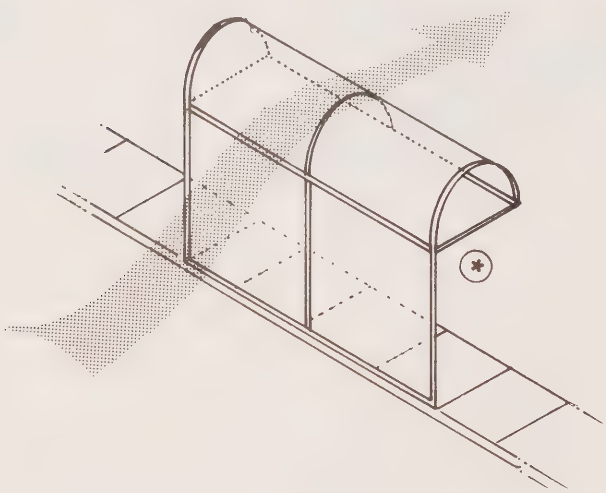
Fig. 2.13



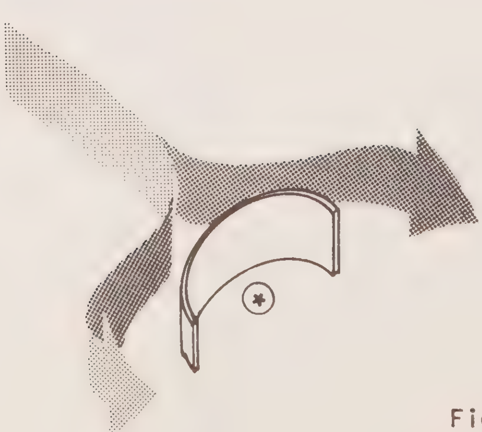

a) A 50% porous screen produces a reduced velocity area for 15H....




b) .... A solid fence for 10



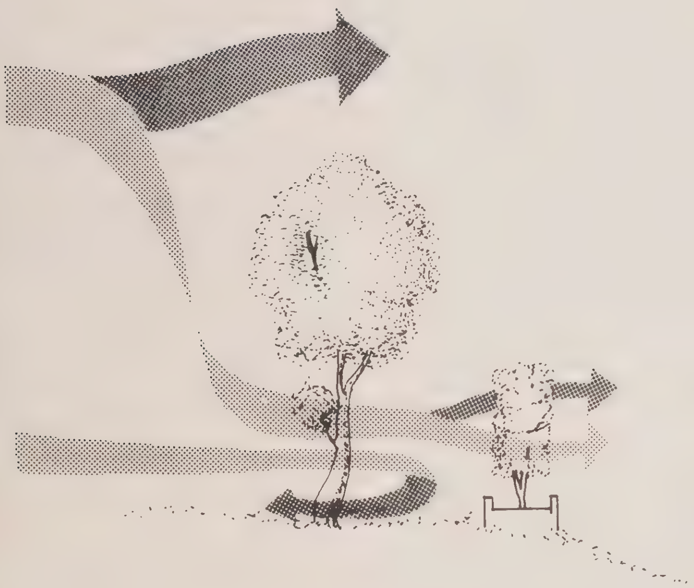
c) Partially enclosed walkwa must be oriented consider ing the prevailing wind directions..............



d) ....Also localized wind shelters.

Fig. 2.14

a) Deciduous trees:- Often do not provide ground level protection - only provide protection during the summer months - are good for forming canopies to reduce downward wind flows.



b) Underplanting will assist in providing ground level protection.

Fig. 2.15

## CLIMATOLOGICAL ACCEPTANCE CRITERIA FOR PEDESTRIAN ACTIVITIES

The comfort criteria presented in Reference 5 are the generally accepted criteria for pedestrian activities. At the conceptual stage of a design the criteria should be used only to plan the usage of different areas and not to accurately rate the acceptability of areas.

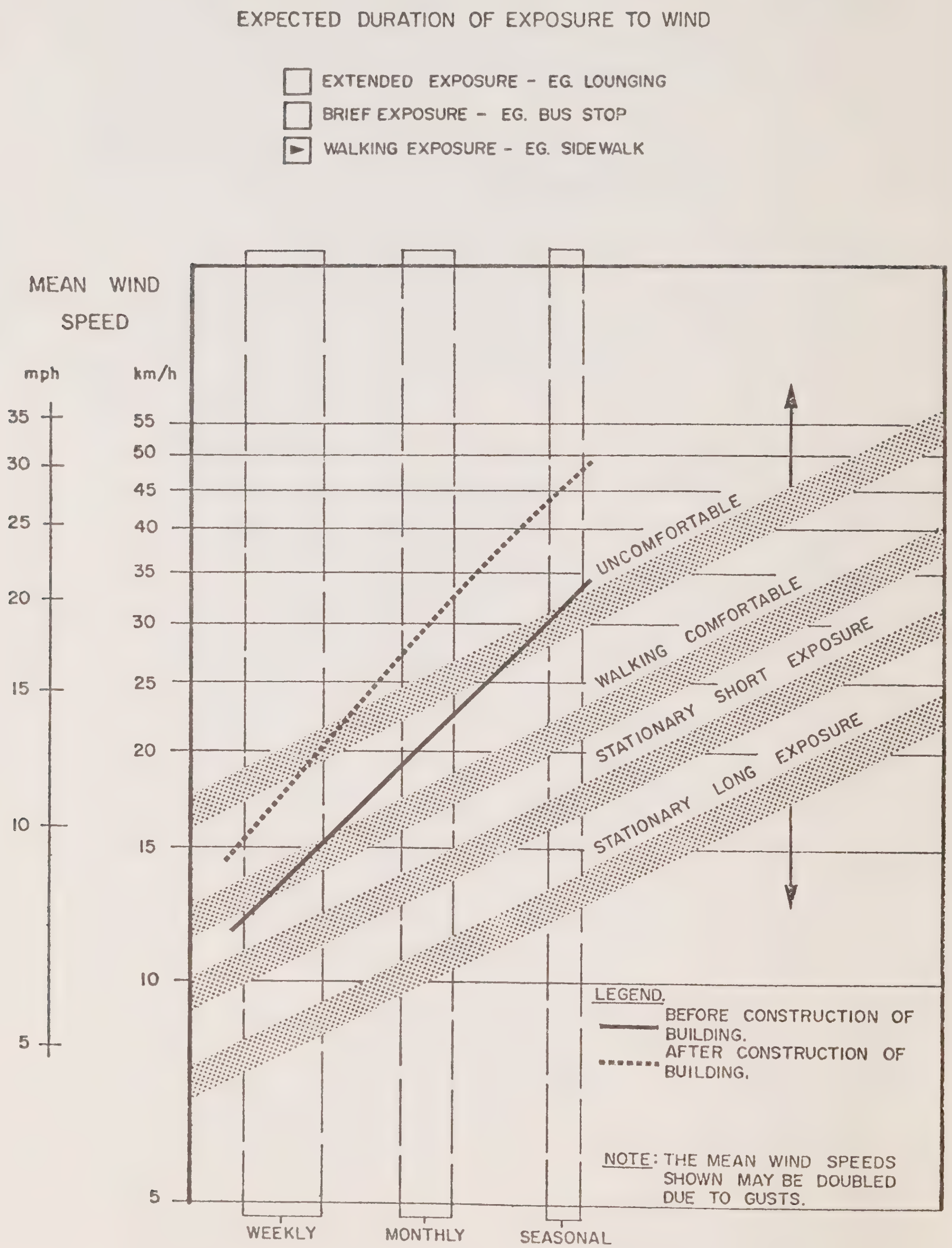
| | | |
|---|---|---|
| i.e. | outdoor restaurants ) | |
| | bandshells ) | LOCATE IN |
| | plazas ) | VERY CALM AREAS |
| | sitting areas ) | |
| | pedestrian gathering areas) | |
| EFFECT OF WIND CHILL | | |
| | landscaped parks ) | |
| | strolling areas ) | LOCATE IN LOW |
| | areas to be used by aged pedestrians ) | TO MODERATE |
| | skating rinks ) | WIND SPEED AREAS |
| | building entrances ) | |
| EFFECT OF WIND CHILL | non-pedestrian podiums ) | |
| | mechanical exhaust ) | MAY BE LOCATED |
| | parking lots ) | IN MEDIUM WIND |
| | wind speed indicators ) | SPEED AREAS |
| | mechanical exhausts ) | |
| | non-pedestrian podiums | MAY BE LOCATED IN HIGH WIND SPEED AREAS |

These criteria become more conservative during the winter time when cold temperatures increase the wind chill factor. This may be allowed for by moving the usage of the areas to a more severe category.

- Areas shaded from the sun will be less comfortable when exposed to the wind.

- Summer activities conducted in direct sunlight will benefit from slight cooling breezes.

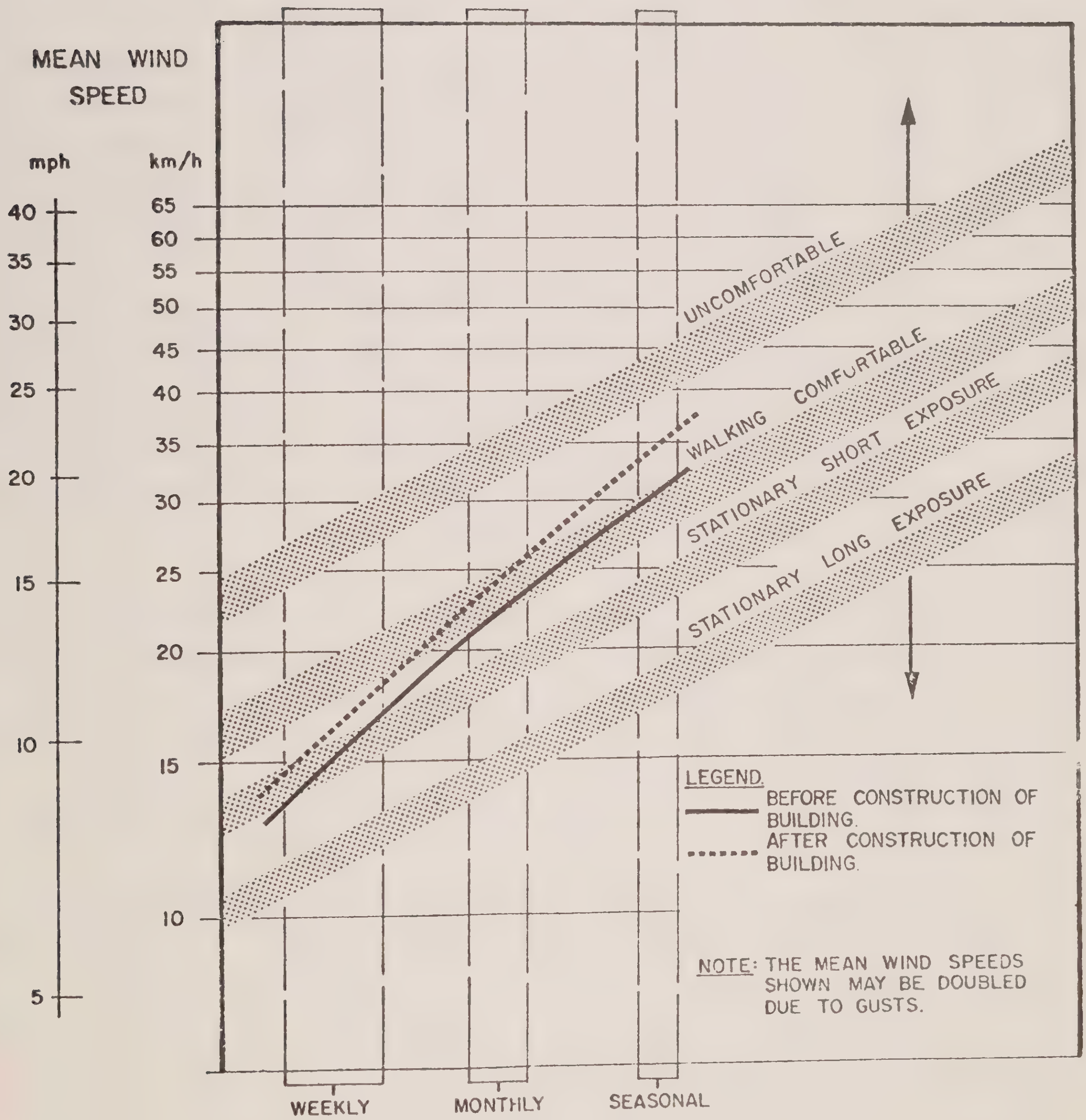
FREQUENCY OF OCCURRENCE OF WINTER WIND CONDITIONS AT POINT (X) AND THE ACCEPTABILITY CRITERIA FOR VARIOUS ACTIVITIES.



FREQUENCY OF OCCURRENCE OF SUMMER WIND CONDITIONS AT POINT (X) AND THE ACCEPTABILITY CRITERIA FOR VARIOUS ACTIVITIES.

EXPECTED DURATION OF EXPOSURE TO WIND

- EXTENDED EXPOSURE - EG. LOUNGING
- BRIEF EXPOSURE - EG. BUS STOP
- ► WALKING EXPOSURE - EG. SIDEWALK



## SEASONAL COMFORT CRITERIA ASSESSMENT

Scale model measurements of pedestrian level wind speeds, together with meteorological data for the site, are used for predicting the frequency of occurrence of wind speeds at certain locations around the proposed building. The likelihood of winds occurring varies with wind direction and season, and this is used in the analysis to weight the test results from each wind direction so that the end result is a realistic estimate of wind speeds to be expected. The resulting wind speed probability distribution for each location considered is compared graphically to a set of activity criteria for the particular season, and point location is then judged on its acceptability for the anticipated use of the area.

The acceptability criteria for various activities are indicated by the shaded lines on the figures of the appendix. The first figure shows the acceptance criteria selected for the summer months. An example of the interpretation of these criteria is that for walking.A weekly mean wind speed occurrence of approximately 12 mph, with gusts up to 24 mph; a monthly occurrence of 15 mph, with gusts up to 30 mph; and a seasonal occurrence of approximately 18 mph, with gusts up to 36 mph, are considered acceptable. The wind speeds considered acceptable for the other activities noted on this figure can be obtained by referring to the relevant location on the vertical axis for the various frequencies of occurrence.

For the winter months the acceptance criteria are naturally more severe due to the effect of wind chill at low temperatures. As shown in the second figure, the acceptance criteria for walking now becomes a weekly occurrence of approximately 8 mph (16 mph gusts); a monthly occurrence of 11 mph (22 mph gusts); and a seasonal occurrence of 13 mph (26 mph gusts), which should not be exceeded.

The first two figures of this appendix are examples of comparisons of the wind conditions at point location "X" on a hypothetical site with the above acceptance criteria. The actual wind conditions which occur before and after construction of a building at location "X" on a site during the summer time are shown on the first figure. Pedestrians will be walking, and not lounging, in this area and therefore the conditions are acceptable. After the building is constructed the conditions will become less comfortable but are

still acceptable. Pedestrian walking in this location during the winter months will experience uncomfortable conditions, both before and after construction of the building, as shown in the second figure. The effect of adding the building is to increase the weekly occurrence of wind speeds from approximately 8 mph to 11 mph and therefore it is considered that the building has not significantly affected the existing conditions.

| CONSERVATION STRATEGIES | | |
|---|---|---|
| | Short Term | Medium Term |
| Operations | stop sign elimination<br>vehicle performance inspection<br>optimization of transit frequencies | exclusive HOV* streets<br>flexible transit—union rules |
| Car/Van Pools | voluntary employer programs<br>HOV* ramps and lanes | mandatory employer programs<br>jitney pickup |
| Auto Restraints | parking rate increase<br>fuel price increase | parking elimination<br>rationing<br>2nd and big car tax penalty |
| Transit Incentives | frequency increase<br>express service<br>special generator service | bus corridors<br>selective investment in light rail transit |
| Travel Reduction | conservation education program<br>4-day work week<br>telecommunications | limit road and transit expansion<br>user pay on transit |
| Land Use | living closer to work | compact and mixed development<br>self-sufficiency of satellite communities |
| Other | procurement practices (i.e. purchasing of energy efficient vehicles) | |
| *High Occupancy Vehicle | | |

Table 6.6.1-$T_3$
Potential urban transportation conservation strategies.[6]

Table from - "Energy conservation: design resource handbook"
The Royal Architectural Institute of Canada

| INDICATION OF AFFECTED ELEMENT WITHIN THE TRANSPORT SYSTEM | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Measure | Reduce trips | Reduce vehicle travel per trip | Reduce vehicle trips | Improve petro-leum effi-ciency of some vehicles | Transfer travel to more petro-leum efficient vehicle | Transfer travel to non-petro-leum using vehicle | Economy and cost effectiveness | Environment | Safety | Implementation | Continuing effectiveness |
| **Comprehensive** | | | | | | | | | | | |
| Curfew | T.O | T.O | T.O | Nil | Nil | Nil | – | ? | + | + | – |
| Driving day ban | T.O | T.O | T.O | Nil | Nil | Nil | – | + | + | + | – |
| **Control inefficient use of vehicles** | | | | | | | | | | | |
| Parking regulation | T.O | ? | T.O | T.O | T.O | T.O | ? | + | + | + | ? |
| Disc for car into city | T.O | T.O | T.O | ? | T.O | T.O | ? | + | ? | ? | + |
| Close roads to inefficient vehicles | T.O? | T.O | T.O | Nil | Nil | Nil | + | + | Nil | ? | ? |
| **Control or influence fuel purchase** | | | | | | | | | | | |
| Ration | T.O | T.O | T.O | O.V | T.O.V.L | T.O.V.I.L | – | + | – | + | – |
| High scarcity market price | T.O | T.O | T.O | O.V | T.O.V.L | T.O.V.I.L | ? | + | – | + | ? |
| Increasing price by tax | T.O | T.O | T.O | O.V.I | T.O.V.I.L | T.O.V.I.L | + | + | = | ? | + |
| Develop non-petroleum fuel | Nil | Nil | Nil | Nil | Nil | V.I | + | + | = | ? | + |
| **Control or influence vehicle efficiency** | | | | | | | | | | | |
| Increasing vehicle efficiency required | Nil | Nil | Nil | Nil | V | V | ? | + | ? | ? | + |
| High tax on inefficient vehicles | T.O | Nil | T.O | Nil | T.O.V | T.O.V | + | + | ? | ? | + |
| **Control or influence use of more efficient mode** | | | | | | | | | | | |
| Public transit more attractive | Nil | Nil | T.O | Nil | T.O.I | T.O.I | ? | + | + | ? | ? |
| Pedestrian zones | Nil | T | T.O | Nil | Nil | Nil | + | + | ? | ? | ? |
| Bicycle and footpaths | Nil | T.I | T.I | Nil | T.I | T.I | + | + | – | ? | ? |
| Ride sharing incentives | Nil | T.O | T.O.I | Nil | Nil | Nil | + | + | = | + | ? |
| Ride on demand, jittney, dial-a-ride | Nil | T | ? | Nil | ? | ? | ? | ? | = | ? | ? |
| Traveller and operator education | T.O | T.O | T.O | T.O | T.O | T.O | + | + | ? | + | ? |
| **Control and management of roadway and infrastructure** | | | | | | | | | | | |
| Improved traffic management | Increase | Nil | Increase | T.O.I | Nil | Nil | + | + | + | + | + |
| Bus and ride sharing lanes | Nil | T.O.I | T.O | O.I | Nil | Nil | + | + | = | ? | + |
| Truckloading zones and facilities | T.O.I | T.O.I | T.O.I | T.O.I | Nil | Nil | + | + | + | ? | + |
| Truck regulation | T.O | T.O | T.O | Nil | T.O | Nil | ? | + | + | ? | ? |
| Freight consolidation | T.O.I | T.O.I | T.O.I | Nil | T.O.I | Nil | + | + | – | ? | ? |

T = Traveller or transport producer
O = Operator of vehicle
V = Vehicle
I = Infrastructure through which vehicle moves
L = Land uses and arrangements of activities

Estimates of magnitude of impacts:
+ (advantage or improvement)
– (undesirable or difficult)
= (no effect)
? (undetermined or highly varied)

Figure 6 6 2.3-T1
Effects of measures to achieve energy conservation in road transportation.[14]

Table from - "Energy conservation: design resource handbook"
The Royal Architectural Institute of Canada

| URBAN GOODS MOVEMENT PROBLEMS AND POTENTIALS | | | |
|---|---|---|---|
| Components | CBD Distribution | Local Distribution | Terminal Intercity Line Haul |
| Problems | Congestion | Congestion | Inadequate Terminals—terminal congestion |
| | Car—bus—truck—pedestrian conflicts | Truck travel through residential neighbourhoods | Proliferation of terminals |
| | Inadequate loading space—on and off street. | Proliferation of lightly loaded vehicles (less than truckload) | Poor rail—truck interchange |
| | Inadequate building design (i.e. elevators) | | Land-use conflicts |
| | Cargo security | | ICC Commercial zone constraints |
| Potential Solutions | Car free zones | Truck Routes | Better intermodal terminal design |
| | Curbside loading zones | Restrict large trucks in residential areas | Expanded commercial zone |
| | Consolidated shipping and receiving areas in office buildings | Traffic engineering—management | Shipment consolidation and transportation facility centers |
| | Urban redevelopment | Curb parking restrictions | Planned industrial parks |
| | Basement truck streets | Dial-A-Bus package deliveries | Truckways |
| | Traffic engineering—management | Truckways | Truck ramps to freeways |
| | Zoning by law changes re: elevators and dock space | Provision for loading in shopping centers | Containerization —unitized cargoes |
| | Relocation of warehousing and wholesaling areas | | |
| | Improved dock designs | | |
| | Parking lot use for delivery trucks | | |

Table 6.6.2.2-$T_1$
Urban goods movement, problems and potentials.[9]

Table from - "Energy conservation: design resource handbook"
The Royal Architectural Institute of Canada

## POTENTIAL MUNICIPAL, SOCIAL AND STRUCTURAL PLANNING INITIATIVES

**Land Use Planning**
- Integration employment, residential nodes with transit
- Compact (integrated, mixed, higher density) land use
- Compatible jobs in residential areas
- Zone for higher overall densities
- Limit number and location of parking spaces
- Multiple and sequential use of transportation rights-of-way
- Complete thoroughfares on local streets
- Mixed use zoning of structures
- Neighbourhood activity centres (nodal concentration commercial activities)
- Reduced parking space requirements for multi-occupancy buildings

**Social Planning**
- Near urban activity centres, parks
- Nonprovision of certain recreational facilities
- Multiple use of schools, municipal buildings in off peak hours
- 3 or 4 day work week experimental programs
- Early retirement programs

**Operational Planning**
- Speed limit enforcement
- Special events generator transit service
- High speed transit service in high density corridors
- Strategic timing, phasing of structural investment
- Vehicle performance testing (public, municipal)
- Increase parking rates, recreation fees
- Public education program on conservation
- Elimination of stop signs
- Low transit fares
- Neighbourhood to node feeder transit programs
- Auto free zones
- Exclusive high occupancy vehicle lanes, corridors

**Administration**
- Municipal taxes on nonresident employees at place of work
- Risk analysis of urban transportation (expressway) investment
- Gasoline price surcharges
- Flexible transit operator rules
- Telecommunications substitution program testing
- Increased property tax on multiple garage dwelling units
- Selective improvement or spot rezoning compatible with existing transportation system
- Tax rebate for living close to work
- Tax credit, loan guarantees for van pool program
- Car/Van pool program promotion

Table 6.6.2.3-$T_2$
Initiatives reducing energy consumption as well as satisfying certain municipal objectives.[15]

Table from - "Energy conservation: design resource handbook"
The Royal Architectural Institute of Canada

| PEDESTRIAN SYSTEMS COMPARED | | |
|---|---|---|
| | Preferred Pedestrian System | |
| Considerations | Above Grade | Below Grade |
| Good personal orientation | ☑ | ☐ |
| Minimum sense of confinement | ☑ | ☐ |
| Proximity to office building employees | ☑ | ☐ |
| Least cost of construction | ☑ | ☐ |
| Minimum disruption to existing buildings or utilities | ☑ | ☐ |
| Ease of system expansion independent of building construction or reconstruction | ☐ | ☑ |
| Minimum cost to control temperature | ☐ | ☑ |
| Ease of direct connection with below-grade transit station | ☐ | ☑ |
| Minimize risk of aesthetic disruption to architecture | ☐ | ☑ |

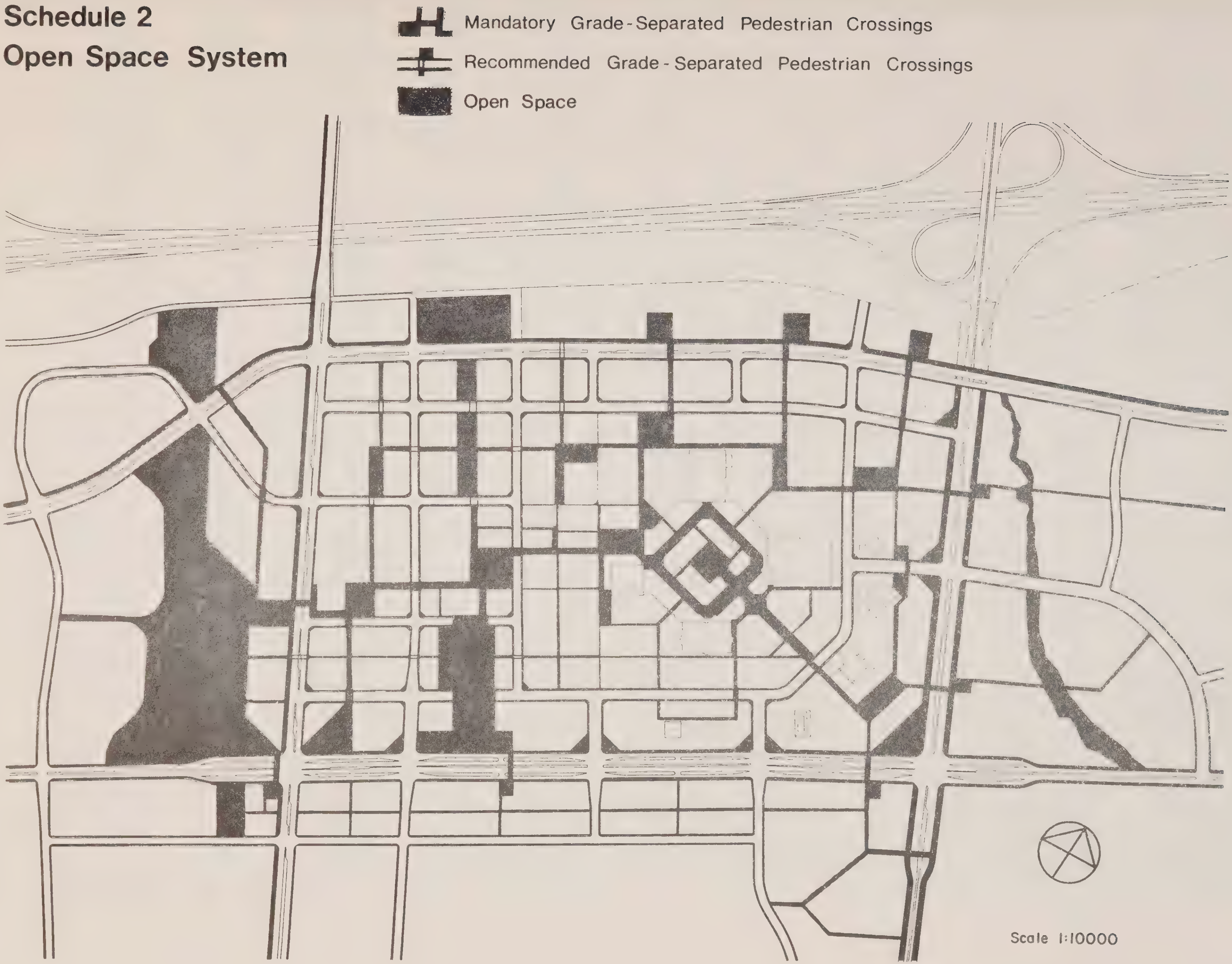
Table 6.6.1-$T_2$
Comparison of above and below-grade pedestrian systems

Table from - "Energy conservation: design resource handbook"
The Royal Architectural Institute of Canada

**A – 281**

## Schedule 2

## Open Space System




Appendix XII f.

DEVELOPMENT POLICIES

A pedestrian network as shown on Schedule 2, Open Space System, will extend throughout the City Centre to link major land uses and to connect development on either side of Hurontario Street and Burnhamthorpe Road. The main pedestrian route within the central pedestrian zone will be between 10 m and 15 m wide and will be interspersed with three major squares of approximately 0.5 ha each, at 200 m to 300 m intervals. The pedestrian network will have two components:

- sidewalks along roadways within their rights-of-way;
- a largely grade-separated system of pedestrian spaces which will be auto-free.

Sidewalk widths along the City Centre roadways will be in accordance with those shown in Appendix B.

The grade separated pedestrian system will consist of open and enclosed walkways, plazas and squares which may be multi-level. It will extend to the City Park at the western edge of the City Centre and will connect recreational and open space throughout the City Centre. It is understood that during the intermediate phases of development some or all of the pedestrian network may be at grade.

The major design objectives of the pedestrian network are set out below:

- protection from inclement weather conditions (wind, rain and snow);
- adequate sunlight penetration during periods of peak use;
- horizontal visual continuity;
- minimum vertical discontinuities or level changes; facilities should be designed to accommodate elderly and handicapped users;
- provision of variety in scale and contrasting experience;
- provision of frequent and convenient access to other transport modes - roads, parking and public transit.

It is recognized that these objectives, by their inherent nature are expressions of general intent, and may from time to time be incompatible with each other. Failure to meet all such objectives at any one time should not therefore be construed as failure to comply with this plan.

Extension of the pedestrian network over roadways will be required at strategic places to provide the continuity essential to the proper functioning of the network. Such crossings may be accomplished by open and enclosed pedestrian bridges and decks.

Pedestrian bridges provide level connections between sections of the elevated pedestrian system. Where a bridge connects two enclosed areas the bridge itself should be enclosed. In the central pedestrian zone construction of shopping facilities on pedestrian bridges will be encouraged in order to provide a continuity in retail frontage.

Pedestrian decks will have direct pedestrian access from all adjacent elevated pedestrian circulation systems and may incorporate features such as landscaping, benches, fountains, kiosks, sculpture and outdoor cafes.

The edges of small squares will be defined by buildings so that space and scale are controlled. Buildings ranging up to 4 storeys will be developed to create a uniform form around the square and taller buildings will be set back from the edges of the square above the fourth floor. Generally it will be desirable to locate the square with an edge along a street.

| City | No. of TOPICS Signals | | Field Study Results | | Estimated Daily Signal Stops | | | Total Time Saved/Day, Minutes | Savings Per Day | | Savings Per Year | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Network Total | Proposed Co-ordinated | % Signals Causing Stops | Av. Delay Min./Stop | Today's Totals | Signal Coordination | | | Fuel in Litres | Costs in Dollars | Fuel in Litres | Costs in Dollars |
| | | | | | | Eliminated | Less Delay | | | | | |
| Alexandria | 90 | 80 | 50.5 | 0.37 | 601 203 | 324 503 | 276 700 | 131 134 | 13 000 | 9 409 | 4 810 000 | 3 434 285 |
| Baton Rouge | 260 | 200 | 66.0 | 0.50 | 2 661 878 | 1 668 826 | 993 052 | 1 003 232 | 31 900 | 65 712 | 21 880 000 | 23 984 880 |
| Lafayette | 100 | 72 | 49.6 | 0.42 | 786 810 | 420 287 | 366 523 | 209 508 | 18 900 | 15 032 | 6 303 000 | 5 486 680 |
| Lake Charles | 134 | 72 | 53.4 | 0.43 | 625 064 | 334 141 | 290 923 | 172 773 | 15 300 | 12 396 | 5 571 000 | 4 524 540 |
| Monroe | 126 | 72 | 44.8 | 0.42 | 638 385 | 281 747 | 356 638 | 150 431 | 13 000 | 10 793 | 4 772 000 | 3 939 445 |
| New Orleans | 508 | 309 | 45.8 | 0.46 | 5 394 800 | 2 697 400 | 2 697 400 | 1 591 466 | 131 000 | 114 188 | 47 869 000 | 41 678 620 |
| Shreveport | 292 | 252 | 24.7 | 0.33 | 1 378 450 | 137 845 | — | 34 461 | 5 000 | 2 473 | 1 771 000 | 902 645 |
| Totals | 1 510 | 1 057 | | | 12 086 590 | 5 864 749 | 4 981 236 | 3 293 005 | | | 101 676 000 | 83 951 095 |

Table title: ESTIMATED FUEL AND COST SAVINGS FOR LOUISIANA'S SEVEN MAJOR CITIES WITH EXTENSIVE TRAFFIC SIGNAL COORDINATION

Table 6.6.3-T1
Estimated fuel and cost savings in Louisiana with extensive traffic signal coordination.

Appendix XII h.

Sample of Lease Clauses re Energy Conservation

Example One:

| | | |
|---|---|---|
| Clause Energy Conservation | (X) | to cooperate with the Landlord in conserving energy of all types in Building and the Project, including complying at the Tenant's own cost with all reasonable requests and demands of the Landlord made with a view to energy conservation; any reasonable capital expenditures made by the Landlord in an effort to promote energy conservation shall be added to Operating Costs in the Year such expenditures are incurred. |

Example Two:

| | | |
|---|---|---|
| Clause Energy Conservation | (X) | depreciation, interest and principal payments on mortgages and other debt costs except that Allocable Operating Expenses may at the discretion of the Landlord be calculated to include depreciation and interest costs with respect to machinery, equipment, systems, property or facilities installed in or used in connection with the building if one of the principal purposes of such installation or use was to reduce other items of allowable Operating Expenses, and also to include reasonable depreciation and interest charges with respect to equipment, such as janitorial equipment, provided or used by the Landlord in the normal maintenance of the building. |

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